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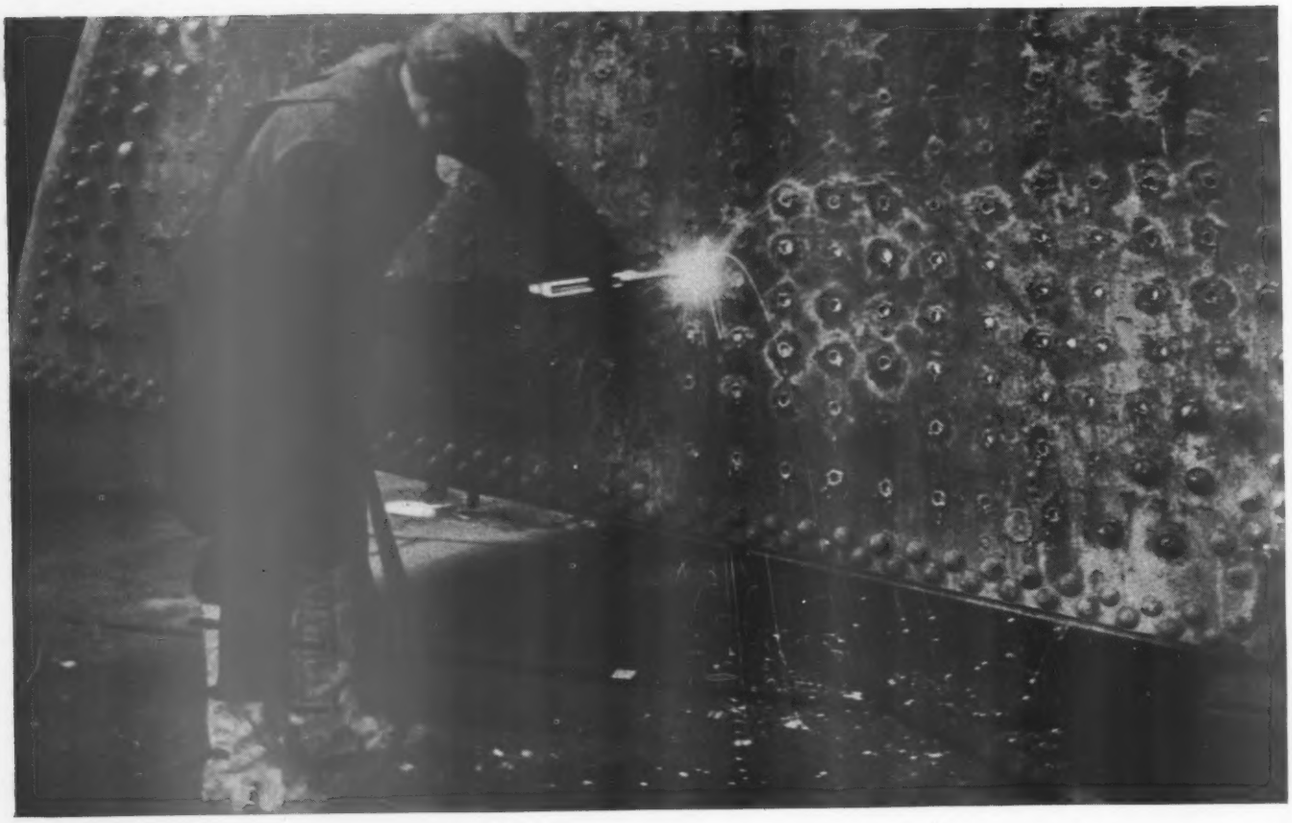

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RAILWAY
MECHANICAL ENGINEER

Methods used on the Canadian National for

Maintenance of Diesel Engines*

By I. I. Sylvester†

Steam-locomotive maintenance methods and organizations as applied to the repairing of Diesel engines and factors involved in the cost of Diesel-engine operation are discussed herein

THE purpose of this paper is to present the results of experience gained in the maintenance of three principal groups of rail-car engines of from 200 to 350 hp., comprising 26 units which have run over ten million miles in passenger service. These engines were placed in service on the Canadian National in 1925, 1927, and 1930, and even though they include improvements evolved over a five-year period, their maintenance problems are almost identical.

Soon after the commencement of Diesel-electric rail-car service, it was recognized that the oil-electric car offered great possibilities for economical operation and high availability, provided a satisfactory program for maintenance could be worked out. The lack of experience and knowledge on the part of those called upon to handle the engines, and of the designer and builder, regarding operating conditions, was a serious handicap in the early days. The seniority system, commonly followed in railway organizations, sometimes mitigated against the selection of the most capable men. Also the locomotive-shop staff had not previously been called upon to perform the type of work required in maintaining the fine working clearances of the wearing parts. However, these conditions have been quite general on railroads on this continent and are mentioned here only because they had such an influence on the amount and type of maintenance required.

The most desirable condition is found in large numbers of identical equipment, centrally located, as expert supervision can be provided and the staff soon becomes accustomed to the new routine. The other extreme is found in rail-car service where the units are operated over an extremely wide territory, which interferes with efficient training and seriously affects availability of the equipment due to deadheading to and from a centrally located repair point. This latter condition applies particularly on the Canadian National, and the maintenance methods which follow were developed to cope with this situation. All these problems have demanded as much attention as the technical difficulties—possibly more.

The engines to which this paper applies in particular are four-cycle direct-injection engines of both British and American manufacture, the original research work having been carried out by the Wm. Beardmore Company at Glasgow prior to 1924 and the later development by the Westinghouse Company at their South Philadelphia plant. The crankcases of these engines are of cellular type, arranged for separate cylinder liners and made of cast steel. The crankshafts are supported in main bearings between each cylinder. Collar studs hold the individual cylinder heads and liners to the crankcase, the main bearings being attached to the crankcase in a similar manner. The crankshafts are of carbon, nickel, and chrome-nickel steel forgings machined all over and drilled for pressure lubrication from the main journals to the crankpins. Cast-aluminum cylinder heads with steel valve seats to accommodate dual inlet and exhaust valves are also used on all these engines. Each head carries its rocker-arm mechanism and a single atomizer which is located at the center of the head where it is easily removed. Aluminum pistons, hollow floating wrist pins, and forged-steel connecting rods are also features of these engines. The development of crank end bearings for the connecting rods has been of considerable interest and will be dealt with later.

The cast-steel crankcase and underbed of thin section, together with rather extensive use of aluminum for such parts as pistons, cylinder heads, and gear cases have resulted in weights between 16 and 24.2 lb. per b.hp. for these engines, which is in the lightweight class for rail service. The essential particulars of these units, which were the subject upon which maintenance investigations were carried out between 1925 and the present time, are given in Table I. These include two columns of figures showing the maximum and minimum sizes, weights, and conditions. The tabulation of the extremes in Table I indicates the design limits of the principal rotating and reciprocating parts around which most of the maintenance problems have centered.

Table I—Principal Proportions of The Diesel Engines

	Minimum	Maximum
Cylinder bore, in.	8	9
Stroke, in.	12	12
Brake mean effective pressure, lb. per sq. in.	77	82.5
Maximum cylinder pressure, lb. per sq. in.	750	800
Diameter of main bearing, in.	5.00	5.00
Length of main bearing, in.	3.70	4.65
Diameter of crankpins, in.	4.75	5.00
Effective length of crankpins, in.	2.29	4.04
Ratio of shaft diameter to cylinder bore	0.555	0.575
Ratio of wrist-pin diameter to cylinder bore	0.315	0.322
Ratio of piston length to cylinder bore	1.4	1.9
Ratio of connecting-rod length to cylinder bore	2.43	2.21
Total weight of connecting rod, lb.	37.94	70.19
Weight of crank end of connecting rod, lb.	26.38	54.09
Weight of wrist-pin end of connecting rod, lb.	11.56	16.11
Weight of piston, lb.	18.19	35.00
Number of pressure rings	4	6
Number of scraper rings	1	3

The first feature of our maintenance consists of daily

* Abstracted from the paper "Maintenance of High-Speed Diesel Engines on the Canadian National Railways," which was presented at the semi-annual meeting of The American Society of Mechanical Engineers held at Detroit, Mich., May 17 to 21, 1937, and published in the May, 1937, issue of the A.S.M.E. Transactions.

† Special Engineer, Operation Department, Motive Power and Car Equipment Sections, Canadian National Railways, Montreal, Canada.

reports made out to show the fuel, lubricating oil, and other supplies used, mileage operated and load hauled, together with any trouble experienced during operation, and finally the repairs and inspection which are made daily. These data are compiled monthly to show the average condition obtaining for each car and, as all the equipment is included in this report, it permits the individual maintainer to compare his performance with that of others. This report also shows any troubles which occur with such frequency as to warrant investigation, thus keeping problems in order of their importance before the supervising staff. An analysis of these records over extended periods of operation also indicates any inherent weakness which can be remedied in new designs.

In a general way the practices developed are a combination of railway maintenance ideas and those used in the repair of gasoline engines. Many of the methods employed are quite in line with those generally accepted in fleet operation of trucks and busses. In fact, much inspiration has been drawn from this source when grappling with the more difficult problems. In these installations engine size and weight have been kept to a minimum with the result that provision for successive wear and remachining is not generally made to the same extent as in steam-locomotive work. One principal difference lies in the rather extensive use of welding and,

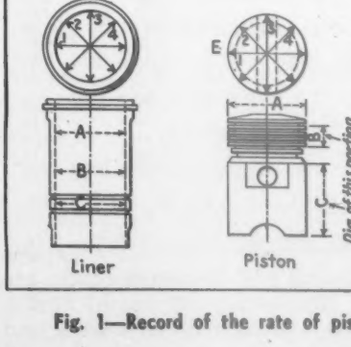
CANADIAN NATIONAL RAILWAYS

OIL ELECTRIC CARS

RECORD OF PISTONS AND LINERS

Car No. 15829
Eng. Type Sackville-six
Eng. No. 116
Date July 30,1929
Miles 82,977

		LINERS				PISTONS				PISTON CLEARANCE	
		1	2	3	4	1	2	3	4	D	E
1	A	8.280	8.281	8.281	8.281	8.215	8.216	8.218	8.217	0.063	0.065
	B	8.251	8.254	8.251	8.254	8.221	8.220	8.228	8.225	0.023	0.030
	C	8.254	8.250	8.247	8.250	8.232	8.235	8.235	8.234	0.012	0.022
2	A	8.256	8.258	8.255	8.256	8.213	8.212	8.219	8.214	0.036	0.043
	B	8.255	8.253	8.254	8.256	8.219	8.220	8.225	8.222	0.029	0.036
	C	8.253	8.251	8.252	8.254	8.232	8.235	8.238	8.235	0.014	0.021
3	A	8.284	8.285	8.282	8.282	8.215	8.212	8.219	8.214	0.063	0.069
	B	8.256	8.252	8.259	8.257	8.221	8.223	8.229	8.223	0.030	0.035
	C	8.253	8.253	8.251	8.253	8.231	8.235	8.241	8.233	0.010	0.022
4	A	8.275	8.275	8.268	8.273	8.209	8.214	8.217	8.214	0.051	0.066
	B	8.257	8.257	8.252	8.253	8.219	8.224	8.226	8.223	0.026	0.038
	C	8.254	8.254	8.248	8.250	8.230	8.236	8.240	8.235	0.008	0.024
5	A	8.270	8.272	8.271	8.269	8.215	8.218	8.217	8.212	0.054	0.065
	B	8.254	8.254	8.252	8.253	8.223	8.225	8.226	8.223	0.026	0.031
	C	8.253	8.253	8.247	8.250	8.235	8.235	8.237	8.236	0.010	0.018
6	A	8.271	8.269	8.268	8.268	8.216	8.218	8.219	8.216	0.050	0.055
	B	8.253	8.253	8.255	8.256	8.222	8.223	8.225	8.222	0.030	0.031
	C	8.250	8.250	8.253	8.254	8.231	8.235	8.236	8.232	0.017	0.019
7	A										
	B										
	C										
8	A										
	B										
	C										



REMARKS

Ring grooves badly worn on all pistons, especially on the exhaust side. Land broken between No. 1, No.2 and No. 3 ring grooves on No. 1 piston.

Recorded at Edmonton
Recorded by [illegible]

CANADIAN NATIONAL RAILWAYS
OFFICE OF CHIEF ELEC. ENGR.
MONTREAL, QUE., DEC.,10,1930

Fig. 1—Record of the rate of piston and cylinder-liner wear

of late, chromium plating as a means for reconditioning wearing parts. Fusion welding, as developed in steam-locomotive service, is now being used extensively in Diesel-engine repairs and much progress has been made in recent years in the use of the electric arc and acetylene flame for the building up of worn parts as well as repairing fractures. Good results were not obtained in this new application without overcoming several technical difficulties because the original development on the railway had to do with structural-steel plates and boiler work in which the metal was quite readily welded. However, in the repair end, large varieties of special metals had to be dealt with and in many instances heat-treatment to regain physical properties of the finished part became a problem.

Considerable ingenuity has been required to develop successful welds on such parts as pistons, cylinder liners, and valve gear. The service engineers of companies which supply welding materials have been of great assistance in the development of suitable welding rods for this work and in providing instructions for their satisfactory use. This process is now responsible for reduction in our maintenance costs and some descriptions of unusual repairs by this method are given under various headings which follow.

Within the last year or so we have been investigating the merits of hard chromium plating in an effort to lower the rate of wear on certain parts and also as a means of regaining the original size where possible. Worn surfaces on pins and journals of crankshafts, wrist pins, cylinders, and various other small parts have been built up with chromium and satisfactorily salvaged. This type of plating must not be confused with the decorative plating which is used more or less in the form of a lacquer to preserve the copper-nickel plating underneath, as it is applied directly to the base metal. We are using thicknesses varying from 0.003 to 0.015 in., depending on service conditions. Excessively thick plates are not found desirable and, for that reason, the original sizes are not always regained.

Cylinders

The cylinders in these engines are in the form of relatively thin tubing, accurately machined all over, and are snugly fitted in the crankcase. They are of the wet type, being surrounded by cooling water, and the joint at the bottom is made by means of rubber rings.

Our lack of information regarding the rate of wear on cylinders and pistons of rail-car engines, some ten years ago, resulted in the introduction of a system of recording the sizes whenever these parts were dismantled. A copy of the form which has been used for recording this information is shown in Fig. 1. At first it was felt that these records would give us an indication of the direction of wear around the circumference of the cylinder and possibly lead to correction of it. However, there was found to be no regularity in this regard, some 60 per cent showing maximum wear at right angles to the crankshaft and the remainder lengthwise or at some intermediate angle. We have been unable, even by painstaking study of a great number of measurements, to associate this feature with any other detail of engine construction or performance. The principal value of this form has been in the determination of average rate of wear on cylinders of different groups of engines, thereby providing a basis for the maintenance program. The comparison of wear resulting from the use of different fuels and of different cylinder materials has also been gained from these records, and they have also shown the accuracy with which replacement cylinders are installed.

A typical example of the location of maximum wear is shown in Fig. 2. This illustration is exaggerated to show the details of the worn portion. Although the wear is always greatest at top dead center, it is rather unusual for it to be almost entirely confined to such a short dis-

tance from top-ring travel. The wear at mid-stroke is always negligible and is only perceptible at bottom dead center on these engines.

What can be accomplished in reconditioning cylinders for further operation is, in the main, controlled by the number of engines involved. Several factors, however, must be given careful consideration, and too much em-

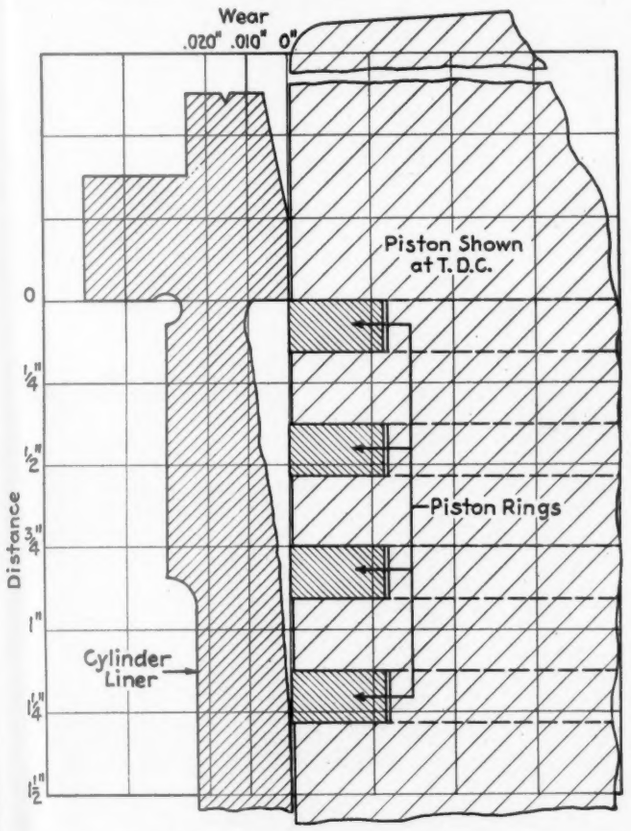


Fig. 2—Location of maximum wear on a cylinder liner—Illustration exaggerated to show details of the worn portion

phasis cannot be placed on the value of accurate measurements of the wear occurring on both the pistons and cylinders. The analysis of these data permits important decisions to be made, such as, whether reconditioning will be necessary and economical on both of these parts or if this attention can be confined principally to the cylinders. Where piston wear is relatively low, it is most economical to regain the original cylinder size by applying a bushing to existing cylinders as in locomotive service, thus avoiding any necessity for work on the pistons or supplying off-size rings.

Fig. 3, which was drawn from an inspection of a large number of forms such as shown in Fig. 1, shows the average rate of wear on the three groups of engines which we have in passenger service. An analysis of cylinder wear on individual engines produces a curve showing a gradual increase in wear up to 45,000 to 55,000 miles and then the wear is accelerated considerably. The shape of the top curve is more in line with the usual individual engine investigations. However, in plotting several hundred measurements, it is impossible to establish anything but a straight line as being the average rate of wear which can be expected. These curves are all the result of wear at top dead center on mild-steel cylinders which are fitted with aluminum pistons.

There are over 150 cylinders of similar type and size in service, which has permitted the establishment of sizes both above and below those which were set up by the manufacturers. It has been found that 1/16-in. wear on the diameter can be economically tolerated, giving due consideration to the increase in lubricating-oil consumption which results from wear on this part. In reconditioning, however, steps of 0.025 in. are desirable and economical in the reclaiming methods described later. It requires about 0.075 in. oversize to clean up properly a cylinder worn 1/16 in. because of the wear being quite eccentric, or otherwise irregular, relative to the center line of the cylinder. In establishing these sizes it has been necessary, of course, to consider them in relation to similar steps on the pistons and the stocking of seven sizes of piston rings to suit. In the beginning, existing cylinders were bored out and oversize pistons applied.

Table II—Sizes and Letter Designations for Pistons and Cylinders

Symbol	Size	Symbol	Size
A	0.075 in. oversize	*E*	0.025 in. undersize
B	0.050 in. oversize	*F*	0.050 in. undersize
C	0.025 in. oversize	*G*	0.075 in. undersize
D	Standard size		

Later, as a result of an accumulation of worn standard-size pistons, undersizes down to 0.075 in. below standard were established. The symbols for size identification, which are stamped on both pistons and cylinders, are shown in Table II.

The arrangement does not require the previous size of the piston to be removed, but merely the addition of the new size. On cylinders, the sizes are stamped on the outside diameter of the collar which extends above the crankcase where it can be observed without removal of the head on most of the engines. The curvature of this surface permits easy removal of the previous size symbol when the cylinder is being rebored.

We are also reconditioning cylinders by depositing a band of metal on the worn portion for about 3 in. down from top dead-center position, with the electric arc. The cylinder is cleaned by grinding with a hand grinder to remove the surface metal and it is revolved during the welding process to keep distortion to a minimum. No attempt is made to regain the cylinder size by this method, but they are bored out about 0.015 in. above the original size and ground to 0.025 in. oversize. This means that a cylinder might be worn 1/16 in., but be

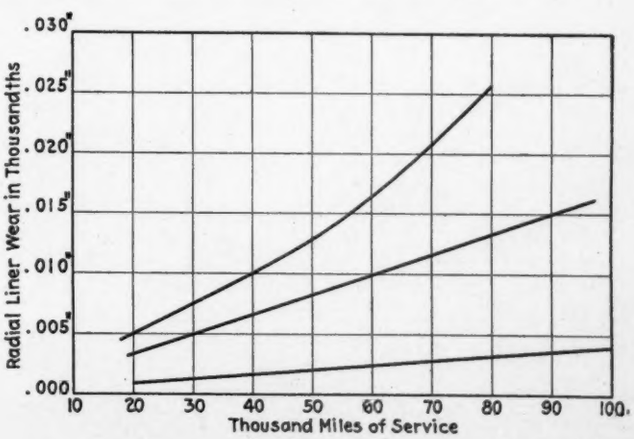


Fig. 3—Average rate of cylinder wear in rail-car engines

returned to service only 0.025 in. larger than previously. A section through the upper part of a cylinder which has been reconditioned in this manner is shown in Fig 4. This enlarged section shows the typical porosity of the electric weld. The deposited metal, however, is considerably harder and more wear-resistant than the orig-

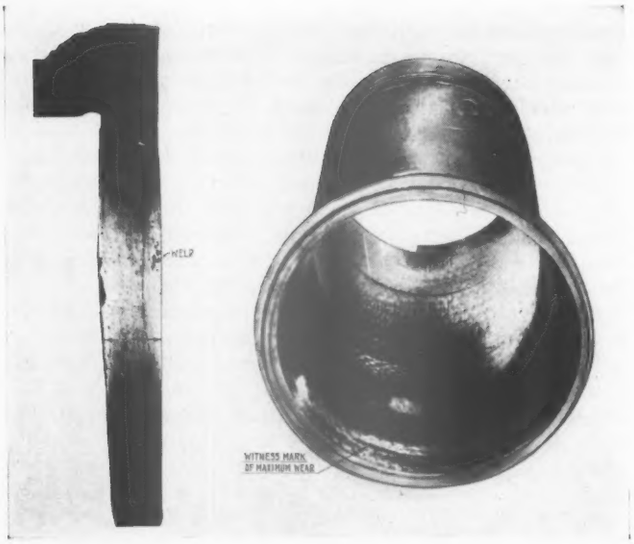


Fig. 4—Left: Worn portion of a cylinder repaired by electric welding—Right: Cylinder liner chrome plated for about 4 in. down from the top-ring travel

inal cylinder material. The pores possibly are an advantage in regard to the retention of lubricant on this zone where the high temperatures often interfere with proper lubrication.

Fig. 4 also shows a cylinder liner from one of the six-cylinder engines which was chromium plated at the worn portion for about 4 in. down from the top-ring travel. This was taken while the cylinder was being reground after plating. It had been worn about 0.024 in. on the diameter and was plated sufficiently to bring it back to standard size and about 0.010 in. to clean it up. The vertical marks from the original use of this cylinder and the ring formed at bottom dead center are noticeable. A witness mark of the groove caused by maximum wear at the top is just in evidence and was removed during the finish-grinding. It is possible to set up these cylinders by the original surface and the measurements indicate that the cylinder is within 0.002 in. of the original size. The results of this application are not yet available. However, it will be watched with particular interest, inasmuch as it has to contend with elevated temperatures as well as abrasion. The fact that chromium is particularly resistant to chemical action of the fuel oil may also provide some data in connection with the "corrosion theory" which is being discussed so extensively.

In addition to harder wearing surfaces resulting from the various reconditioning methods which have been used on mild- and tempered-steel cylinders, some very interesting information pertaining to the use of cast iron and nitrided steel for this purpose has been developed on these engines.

In the application of cast iron in place of steel, it has been necessary to reduce the cylinder size somewhat in order to provide sufficient strength, and this may have had an influence on the results. We have been unable to find a great difference in rate of wear on nickel iron, ordinary gray iron, or iron cast centrifugally. Any of them, however, appear to wear only about half as rapidly as mild steel. The greatest difficulty with the use of this metal on these particular engines, which were designed for steel cylinders, is in the application within the narrow confines of the crankcase.

Cylinders of nitralloy steel are giving a very creditable performance. Tests have been carried out over 259,000 miles in obtaining comparisons. These indicate that the maximum wear is 0.007 in. in 80,000 miles, which is only about one-fourth to one-fifth the amount on mild steel in similar service. The attempts which have been made to reclaim any cylinders of this material are unprofitable because of the difficulty in grinding the excessively hard surface. Also the second wear is inferior because the surface hardness is removed.

The pitting of the steel cylinders, as a result of the action of the cooling water on the outside, is also a problem which has been dealt with in maintenance. Zinc and aluminum spraying of some of the cylinders has been used to prevent this action in order to continue the cylinders in service for a longer period. A certain amount of pitting occurs at all times, but usually the cylinder is worn to the limits mentioned before serious weakness results. A limit of $\frac{5}{32}$ in. wall thickness, measured at the bottom of the deepest pit, has been set up for steel cylinders in order to avoid this condition. All liners are coated with a corrosion-resisting paint during manufacture or reconditioning to counteract the attack of the cooling water. No trouble whatever has been experienced with pitting on cast-iron or nitrated cylinders.

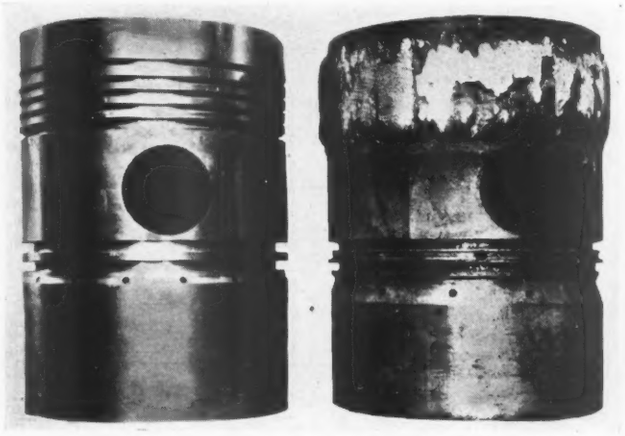


Fig. 5—Left: Piston which had the ring belt machined off, acetylene welded, heat-treated and machined—Right: The piston before machining

Pistons

Of the various wearing parts of these engines, the pistons present the most complex problem, and have been the subject of considerable study both as to design and maintenance. The almost continuous variation in speed and load over wide ranges, which has to be dealt with in railway traction, makes greater demands on the piston than most services. Further, the introduction of aluminum-alloy piston, so essential to these high-speed, light-weight engines has tended toward higher lubricating-oil consumption—first, because of the varying clearances between the piston and cylinder resulting from the previously mentioned service requirements; and, second, because the comparatively soft aluminum alloy wears more rapidly than other piston materials.

Considerable painstaking work and time have been necessary in developing maintenance methods to meet these conditions. However, a very satisfactory reduction in lubricating-oil consumption and reconditioning these parts has followed our efforts and we have been enjoying the benefits for several years.

Of the sand-cast, die-cast and forged-aluminum pistons which have been employed since 1925, the forged metal is most suitable, as it is stronger, more ductile and wear-resistant. It is more expensive, however, because of the

more costly process of manufacturing the metal and machining this part from the solid forging.

Wear of the ring grooves in any of the alloy pistons appeared as a difficulty early in the operation of these engines. It was, in fact, this item which determined their useful life. In bringing this factor within reasonable limits, it has been necessary to consider the effect of the fuel oil as well as the design and metal from which the pistons are manufactured. In the early days, fuel specifications were written in broad terms to take care of the very wide territory in which these engines operated. However, it seems that two fuels can have apparently identical physical characteristics and yet the reaction on the piston from a wear standpoint may be widely different. Improved fuel specifications, which have been developed, and the adoption of narrower and diametrically thicker rings proved helpful. However, there was still the necessity for reconditioning the ring grooves. Wear on the top grooves has been limited to 0.006 in.

Fig. 6—Enlarged section of a piston before being acetylene welded

and when this is exceeded the grooves are machined out to take overwidth rings. It has been proved that good piston rings in equally good grooves are steps in the right direction, and much of our effort has been directed toward this end.

Engines such as these, designed with minimum weight, of necessity have the wrist-pin hole somewhat above the center of the piston, which has a very limiting effect on the width of the lands between the piston rings. This restriction does not allow for much widening of the groove until the land is altogether too weak and subject to breakage. We have, therefore, limited this feature of our reclaiming operations to 0.025 in. over standard width. The rate of wear on the ring lands remained so much greater than that occurring on the rubbing surfaces of the piston or wrist-pin hole that there are many pistons which could be used further provided the original condition could be regained at the ring belt. To accomplish this, acetylene welding is being employed and, in Fig. 5, at the right, is shown a piston which has had the entire ring belt machined off and new metal deposited by this method. At the left appears a similar piston after heat-treatment and machining. In the investigation prior to the adoption of this method, sand-cast and die-cast pistons were examined both before and after welding, and some of the results are shown in Fig. 6. This shows an enlarged section of an unwelded piston located in this work. This particular one is somewhat worse than average regarding porosity. Fig. 7 shows a section illustrating a welded piston, for comparison; this enlargement shows the condition of the welded ring belt after machining. It will be noted that the porosity even in the newly deposited lands is not nearly as serious as in the original casting shown in Fig. 6. The strength of original and welded lands on pistons was determined by the load required to break them off one at a time. Typical loads required to break lands off an original piston are 35,000, 36,000, and 35,500 lb. while typical loads for a welded piston are 60,000, 66,000; and 64,000 lb.

The machining of the outside diameter of the pistons has been treated in line with that described for the cylinders. The welded pistons are always machined down 0.025 in. in diameter which removes any distortion caused during the welding process. The wrist-pin holes were found to close in slightly under this treatment and this is an advantage, since it permits the wrist pin to be refitted to standard clearances.

In connection with newly manufactured pistons of 8 to 12 in. diameter, it has been demonstrated repeatedly that a certain amount of distortion takes place soon after they are placed in service, and, in connection with reconditioned parts, this does not seem to be noticeable. In the ordinary course of events, pistons which have been reconditioned after 75,000 miles have been fitted with smaller clearances without any evidence of seizure.

Diesel-engine crankshafts are handled in a manner similar to the pistons and liners in regard to records of

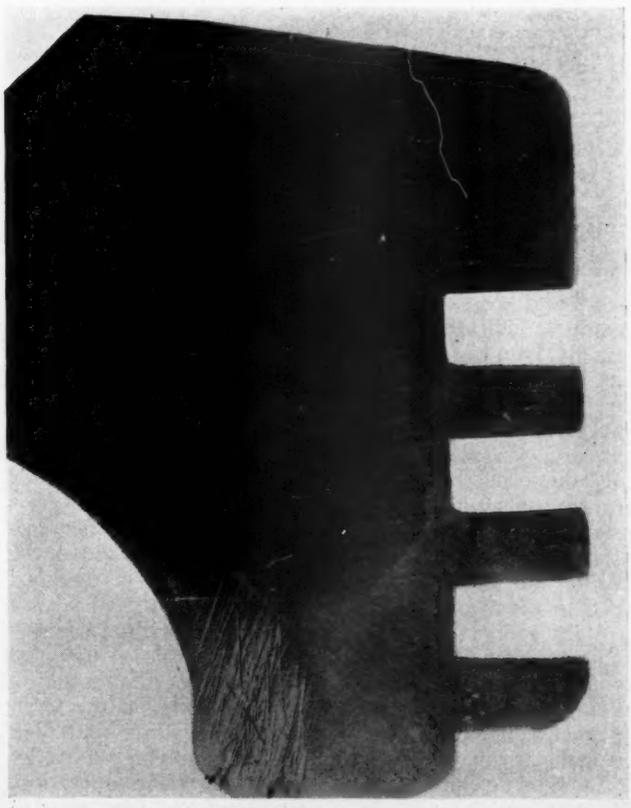


Fig. 7—Enlarged section of a piston after being acetylene welded

wear and sizes. In Fig. 8 is shown a copy of this form which is typical of the wear occurring on this part. In some studies made several years ago comparisons were made between nickel, chrome-nickel, and carbon steels for wear resistance, and it was found that there was very little choice between them. However, in replacement, the trend has been toward alloy steels because of the harder bearing surfaces and greater strength. On main journals, the wear varies between one and two thousandths on the diameter in 100,000 miles and the crank-

CANADIAN NATIONAL RAILWAYS

OIL ELECTRIC CARS

RECORD OF ENGINE SHAFT MEASUREMENTS

Car No. 15899
Eng. Type Beardmore-215
Eng. No. 115
Date January 20, '31
Miles 199,548

		Diameter of journals		Difference		Diameter of crank pins		Difference	
		F	R	V-H	F-R	F	R	V-H	F-R
1	V	4.9980	4.9940		0.0020	4.7280	4.7300		0.0020
	H	4.9980	4.9965		0.0015	4.7280	4.7300		0.0020
2	V	4.9960	4.9960		0	4.7290	4.7320		0.0030
	H	4.9950	4.9955		0.0005	4.7300	4.7315		0.0015
3	V	4.9950	4.9950		0	4.7270	4.7310		0.0040
	H	4.9955	4.9955		0	4.7275	4.7320		0.0045
4	V	4.9940	4.9925		0.0015	4.7325	4.7345		0.0020
	H	4.9935	4.9935		0	4.7335	4.7355		0.0020
5	V	4.9940	4.9945		0.0005	4.7290	4.7320		0.0030
	H	4.9950	4.9960		0.0010	4.7305	4.7315		0.0010
6	V	4.9960	4.9970		0.0010	4.7315	4.7325		0.0010
	H	4.9960	4.9965		0.0005	4.7325	4.7335		0.0010
7	V	4.9950	4.9960		0.0010				
	H	4.9965	4.9975		0.0010				
8	V	4.9950	4.9955		0.0005				
	H	4.9965	4.9970		0.0005				
9	V								
	H								

NOTES

F = Front nearest to gear case
R = Rear
V = In vertical plane
H = In horizontal plane
Difference between V and H indicates ovality and should be zero.
Difference between F and R indicates and should not exceed 0.002 in.
When being measured the crankpin to be on top dead center.
If serious ovality is found on main journals, the measurements shall be recorded in relation to a top dead center.

Gearcase End

Shaft No. 35263 M 1097

Recorded at Winnipeg, Man.
Recorded by Geo. F. Shaw

CANADIAN NATIONAL RAILWAYS
OFFICE OF CHIEF ELEC. ENGR.
MONTREAL, January 30, 1931

Fig. 8—Form for recording rate of crankshaft wear

pins show six to nine thousandths during this period on the usual run of crankshaft steel.

The Nitralloy crankshafts which were applied several years ago are standing up remarkably well, and, on the average, indicate the wear to be about one-sixth that usually found. In practically every instance, regardless of the type of steel, however, the crankpin wear is four to five times that found on the main journals. In reconditioning crankshafts the practice is to turn the crankpin and journal which is in the worst condition first, and then use the size which has been thus established for the remaining pins and journals. In this way it is not found necessary to establish definite undersizes for this part, and in a measure this has extended the life of the shafts, as only sufficient metal is removed to true them up.

Very good results have been obtained with a Webber tool in turning crankpins. This tool is one of the type which is used in the lathe and follows the crankpin around in its normal path when revolving on the main journal centers. Any pins which are oval are first filed to make them round so that the tool will be guided by a fairly true surface throughout the entire operation. Wooden polishing blocks are employed and fine abrasive compounds are used in the final finishing, producing accuracy in line with manufacturers' required tolerances.

Correcting-Rod Crank Bearings

One of the problems which developed in the early use of these engines, and for which the maintenance staff was obliged to find a solution, related to crank-bearing failures. This amounted to cracking of the babbitt lining in the rod or top half of the bearing which continued until most of the babbitt in the high-pressure area was loose and broken in small pieces. If this condition was not detected, the detached pieces pounded out until they interfered with lubrication, causing heating, or the bearing shell came down on the crankpin. It was found that it did not take long for most of the babbitt to become loose after the initial crack had formed and it was not unusual for loose babbitt to go unnoticed until the bearing was removed for inspection. The loose pieces would, of course, fall out when the bearing was disturbed, and renewal was necessary. Cracking never occurred in the bottom half of the bearing and the main bearings also were practically trouble free. The fact that the babbitt metal employed included all the popular tin-base alloys and from failures which occurred with several of these which were applied under expert supervision, there was a strong belief that the loads were too high. To offset this, however, a study of the records indicated that some bearings operated in excess of 200,000 miles without renewal. These, of course, were rather exceptional in the early days. However, these rare occurrences indicated the direction of improvement, and final solution of the problem followed.

Table III—Analysis of Bearing Material

Element	Babbitt, per cent	Lead-bronze, per cent
Copper	1.00	77
Lead	78.75	15
Tin	1.25	8
Antimony	18.00	..
Arsenic	1.00	..

Flexing of the bottom end of the connecting rods was given attention and, in later installations, bearing sizes were increased and the rods strengthened. However, the trouble continued and, at one stage of the investigation, several methods of babbitting the crank bearings were tried. These included babbitting direct on the steel rods without the use of shells, and the use of bronze-lead combinations which were only partially successful. The experience which was gained resulted in some very definite ideas regarding the best type of crank bearing for railway traction.

Protection of the crankshaft against damage under severe and abusive conditions is an important factor because passenger trains must be on time if humanly possible. This means that under abnormal conditions an engine may be operated without a proper supply of lubricating oil, with disastrous results. The development of a crank-bearing shell which can be operated after the babbitt has disappeared without damaging the shaft is the answer. The use of a shell of this type which can be easily removed for inspection or replacement, has permitted reasonable maintenance and provided good protection for the crankshaft.

As a consequence of the poor results obtained with the bearings in the early days and the time required to obtain replacements and deliver them to remote parts of the railway system, attempts were made to manufacture bearings in the railway shops. At first these were not very successful, but by the use of special babbitt with high lead content, together with improved practice regarding its application, the crank bearings have ceased

to be a troublesome feature in maintenance. Lead is usually thought of as an extremely soft and ductile metal. However, the addition of antimony and arsenic gives it a surprising hardness without interfering with its antifriction qualities.

Bronze shells with a phosphorus content were also found to be unsuitable and the best results are being obtained with babbitt, and shells of the composition given in Table III. The jig which is employed is made solid in order to retain the heat and it is kept between tempera-

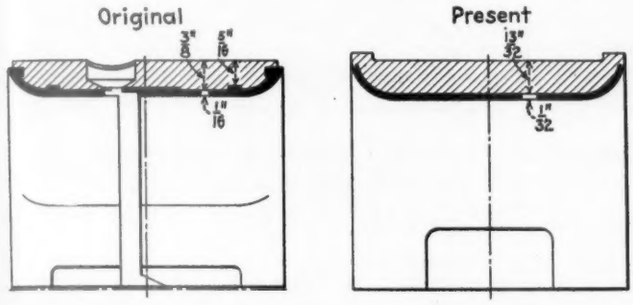


Fig. 9—Changes in design of connecting-rod crank bearings which have increased the service life of the bearings—These bearings are for an engine with the following characteristics:

Diameter of crankpin, in.	4.75
Original effective length of crankpin, in.	2.043
Original projected area of connecting-rod crank bearing, sq in.	9.7
Pressure, lb. per sq. in., gas load only	4,400
Pressure, lb. per sq. in., gas inertia	3,560
Rubbing speed, ft. per sec.	16.5
Number of bolts in crank end of connecting rod	2
Capacity of lubricating-oil pump at 800 r.p.m., gal. per min.	34.1
Number of cylinders	6
Engine speed, r.p.m.	800

tures of 250 and 300 deg. F. The tinning bath is composed of babbitt containing 70 per cent tin and 30 per cent lead solder, maintained between temperatures of 600 and 650 deg. F. Considerable care is exercised in maintaining the babbitt pot at 1,050 deg. F., and the molten metal is poured from a ladle previously raised to the same temperature. This ladle is of a large size enabling a complete pour to be made in one operation. The shell is not removed from the jig until it has cooled to 225 deg. F.

During the tinning process the shell is completely immersed in the bath and left until it has reached a uniform temperature, being removed to coat it with soldering flux. This, briefly, is the practice employed during the process and great care is exercised to insure cleanliness and accuracy.

The rough hammer-and-chisel maintenance methods credited to the railway organization no doubt caused unnecessary failures, but this same method applied to the babbitt of the big-end bearing resulted in a test definitely proving the degree of adherence between the babbitt and shell. When this chipping test showed that there was no tendency for the babbitt to peel away from the shell, an almost perfect bond existed between the two metals. The feature since that time has been only the reproduction of the conditions under which this satisfactory bonding occurred, and in this respect the human element plays an important part. There is now only an occasional bearing which shows trouble on inspection, and the average life of these is well above 100,000 miles. Most of the engines go from shopping to shopping without renewal.

In the manufacture of bearings, certain slight changes were found beneficial. These are illustrated in Fig. 9 and show the details of a bearing which was one of the worst offenders, together with particulars of the working conditions. Fig. 9 shows the original design and the improvement which has been in successful operation for several years. Anchor grooves and oil grooves were eliminated and the babbitt thickness has been materially reduced. Oil pockets were cut at right angles to the rod center line and end collars have been added.

Bearings of 4¾ to 5 in. diameter are installed with only 0.001 to 0.002 in. clearance, and operate at normal temperatures with clearances of 0.003 in.

General

A certain amount of distortion is found in the main-bearing openings of the crankcases after several years of service. However, the practice of line reaming the main bearings in place, which has been adopted, takes care of this. The slight differences in babbitt thickness which results from this practice is of no consequence. The same type of bearing is used in the mains as in the connecting rods previously described. Extremely long life is obtained from these. However, in the ordinary course of events they are renewed at each general overhaul when the crankshaft is reconditioned. In other words, these bearings do not wear out but are replaced with bearings of smaller size to accommodate the reconditioned shaft.

The reconditioning of aluminum cylinder heads with steel valve seats has presented no problems uncommon to automobile engines. Occasionally a head will become bustion-pressure area, it is repaired by welding. A 50-lb. hydraulic test of the water space is made following such repairs. Reaming of the seats is required at periods of 100,000 miles. Exhaust-valve guides also require renewal at this period.

The four-cylinder engines have been practically free from any renewal of parts in the gear cases in spite of mileages around 500,000. On the six-cylinder engines,

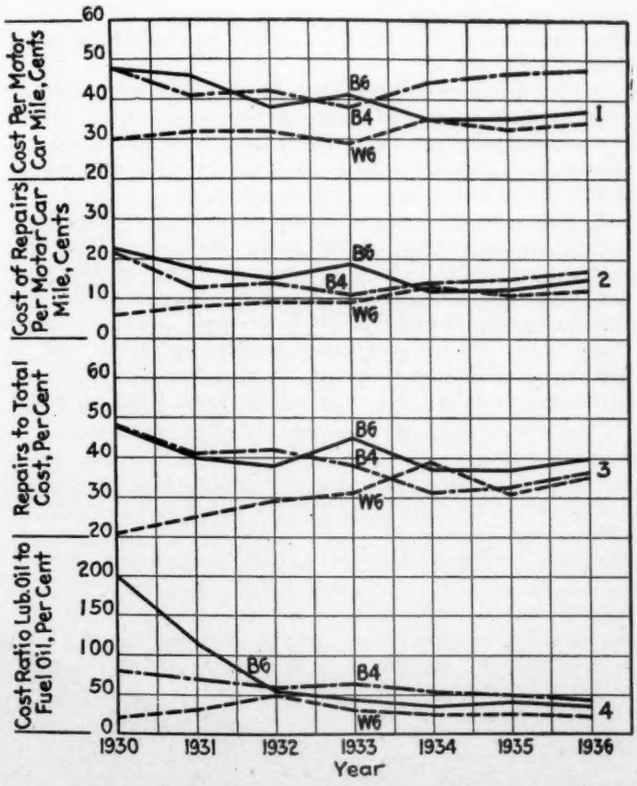


Fig. 10—Cost per car mile for Diesel-electric operation

During the period shown in this figure the engines were operated an average of 192 miles per day—The letters on the curve refer to Beardmore four- and six-cylinder and Westinghouse six-cylinder engines

however, this unit becomes noisy at about 150,000 miles and will require renewal of gear-case parts at 200,000 miles. It is likely that the difference in torsional vibration is responsible for this, and on some occasions it has been noted that early trouble with the gears was associated with an improperly adjusted vibration damper.

The type of wrist pin with which these engines are fitted, which is free to revolve both in the piston and the bearing, is very easy to maintain. It is only in the last few years that they have required any attention. Wear of 0.006 in. is the maximum which has been found even after many years operation. This is rather surprising as the loads on this part are high. The wear on wrist-pin bosses in the piston and also in the rod bushing is relatively low, and the only measure which has been taken to regain the original clearances on worn parts is in providing 0.005 in. oversize pins by means of chromium plating.

Fuel-injection pumps and atomizers are sent in to a central repair shop which is adjacent to a toolroom equipped to make adequate repairs. Plungers and valves are reduced in diameter 0.003 and 0.005 in. as required, and new bushings are fitted. Considerable technique has been developed in this work, and lapping of the parts which at one time was a tedious job has been cut to a minimum. Each pump unit is given a static test of 5000 lb. pressure as an initial check for leakage. The completed pump is put on an operating test and the fuel quantities balanced using the atomizers which are to be installed with it.

Governors, lubricating-oil pumps, water pumps, and primary fuel-oil pumps operate over 200,000 miles between shopping periods without trouble. Often these will go to the third general overhaul before requiring much attention. Two or three spare units of each type have been provided for protection and are handled similarly to pistons and liners, being repaired at a central shop and sent to outlying repair points as occasion demands.

Some further impressions of the average mileage which is being obtained from various engine parts under the maintenance practices which have been described are shown in Table IV. This also shows data relating to the limits of wear which are in effect.

Further details of the more important factors pertaining to the cost of maintenance are included in Fig. 10 for years 1930-1936. The average trend of total cost per mile, shown in curve 1, has been downward to 1934 and has held between 36 and 40 cents per mile since then. One of the greatest influences on total cost is total miles and, unfortunately, as a recent of alterations in train schedules, the runs which have been operated by this equipment are shorter than previously. At one time groups of these cars were on runs of 300 miles per day and this dropped to 220 miles in 1929 and has made a further drop of 13 per cent since. The fact that repair cost has held constant, or been slightly lowered, as shown in curve 2, in spite of this, is very gratifying. It has been impossible to obtain the cost of engine repairs separate from the other mechanical and electrical repairs. However, the fact that there has been a general improvement in this is seen from curve 3, which gives the repairs in per cent of total cost. Last, but not least, in curve 4 is shown the very satisfactory reduction in lubricating-oil consumption which has resulted from a systematic handling of pistons and cylinder-liner repairs.

Table IV—Maintenance Practice of Diesel-Engine Parts

Part	Limits of wear	Average mileage	Type of repairs
Crankshaft	0.006 in. out-of-round on two or more crankpins	250,000	Recondition
Cylinders	Worn between 0.045 and 0.06 in. on diameter	150,000	Recondition
Pistons	Worn 0.01 in. above top ring; 0.006 in. clearance in three ring grooves; 0.005 in. clearance in wrist-pin hole	100,000	Recondition
Connecting-rod bearings	Clearance maintained between 0.003 in. and 0.004 in. by adjustment of shims	No record of worn out bearings	
Wrist pins	Worn 0.006 in. on diameter	300,000	Renew
Exhaust valves	Renew when bent, warped, or stem worn 0.005 in.	75,000 200,000	Grind Renew
Exhaust-valve guides	Renew when worn 0.008 in.	100,000	Renew
Piston rings	Gap opening increased to ⅛ in.	75,000	Renew

Some ideas on depreciation of Diesel-engine equipment can be gained from our experience. In the first place the results after 12 years with the oldest engines indicate that an estimated life of 20 years is conservative. The possibility of engines of this type becoming obsolete or the costs rising to where they are uneconomical after extended service is remote. By inexpensive investigation, it is possible during overhaul to improve and modernize the engines, even within the narrow confines of existing crankcases, with beneficial results. Finally, by careful records of wear being kept, a systematic handling of repairs can be set up which results in a lowering and stabilizing of engine-repair costs. Up to the present it would appear that depreciation is practically taken care of by renewal of the active parts.

* * *

Application in Car Construction of

High Tensile Steels*

By A. F. Stuebing†

Simple precautions for welding and forming high-tensile steels —Economies possible by their use in the rebuilding of cars

The proceedings of one of the earliest meetings of the Master Car Builders' Association record that in 1871 that organization passed a resolution calling on the railroads to build light-weight freight cars for experimental purposes. However, it seems that the car builders found the design of a practical light weight car a difficult problem and not one was constructed during the following year.

It is interesting to know that even sixty-six years ago car-department officers realized that the weight of cars was a major factor in economical railroad operation. In later years, substantial progress in weight reduction was effected by the use of stronger materials and by refinements in design. Recently, this problem has again assumed increasing importance due to changing operating conditions. In 1920, the ton miles of dead weight and of pay load which the railroads hauled in freight trains, excluding the locomotive and tender, were approximately equal. In recent years, the dead weight has been about one and one-half times as much as the lading. In passenger service, the need for light-weight equipment is self-evident to permit economical operation at the high speeds that are now being adopted for a large proportion of the through trains. Ralph Budd, president of the Chicago & Quincy, has stated that, if the weight of all passenger and freight cars in this country could have been reduced by one-fourth, the saving to the railroads in 1937 would have been $154,000,000.

Fortunately, the railroads now have available a practical means of effecting the reduction mentioned by Mr. Budd. It can only be done gradually as new equipment is obtained or cars are rebuilt, but a good start has already been made. In the last three years, over 16,000 freight cars and 600 passenger cars have been built of a new type material especially adapted for car construction—namely, high tensile steels.

Characteristics of High-Tensile Steels

Before proceeding to discuss the application of these materials, it may be well to outline in a few words their salient characteristics from the standpoint of car construction. Briefly stated, the high-tensile steels are a new group of materials which, as-rolled, without any special treatment, provide a combination of high tensile strength and ductility previously available only in heat-treated steels. Most of these materials can be readily welded by the autogenous process. Some possess superior resistance to atmospheric and other kinds of corrosion to which car equipment is subjected.

All of these high-tensile steels cost more per pound than mild steel, but some now cost no more per unit of strength. However, the unit price of the material is often a minor factor, as is shown by the fact that light-weight high-tensile-steel freight equipment, designed to provide strength and life equal to conventional cars, costs no more per ton of capacity.

The savings that can be effected by reduction in the weight of cars have been discussed in detail in several papers. It has been pointed out that high-tensile steels can be used for increased strength and lower maintenance on the one hand, for weight reduction and savings in operating expenses on the other, or in a compromise between the two objectives.

In the majority of cases, the objective sought by the application of high tensile steel will be reduction in weight, in order that more efficient load ratios may be achieved with consequent operating economies. These savings usually far out-weigh considerations of reduced maintenance and added life beyond the normal term of conventional equipment. Most designs of railroad equipment use high-tensile steels conservatively. Such cars provide greater strength, in addition to better load ratios, and will have lower maintenance cost and longer life.

The physical properties of high-tensile steels adapt them for use in types of equipment which must withstand unusually severe service, such as mill-type gondolas, mine cars and dump cars. Even in the case of such equipment, it has been found practical to make some reduction in weight by decreasing sections in many parts of the car structure.

Design Considerations

The application of high-tensile steels requires changes in practice and introduces some new problems in design and construction. It is often difficult to escape the idea that bulky members are necessary for strength. The opinion has been expressed that center sills, because they are subjected to severe shock, should have sections approximately equal to those used in standard constructions, even when built of high-tensile steel. Certainly any one who recalls the troubles caused by some of the early applications of light-weight center sills, many without cover plates, made about thirty years ago, and the excessive repair costs which they entailed, will agree that it is important to have adequate strength in the underframe construction of any car. However, if the strength required to withstand the maximum forces can be obtained with relatively smaller cross-section area, such a construction is advantageous. Draft-gear tests, conducted by actual car impact, have demonstrated that the resiliency inherent in the car structure is an important factor in supplementing the capacity of the draft gear. The greater the amount of this resiliency, the lower will be the ultimate force in a given impact. Consequently, the use of a smaller cross-section of a material adapted to withstand higher unit stresses will result in added protection to the car, provided the maximum strength of the center-sill construction is adequate.

Questions frequently arise regarding the reduction from the thickness or cross-sectional area of carbon-steel parts that is permissible when high-tensile steel of certain known physical properties is used. No simple rule

* Presented at the Convention of the Car Department Officers' Association held in Chicago, Wednesday, September 29, 1937.

† Railway Mechanical Engineer, United States Steel Corporation.

can be given for determining the proper reduction for all applications. If members are used in direct tension so that the stress varies directly with the cross-sectional area, the section used may be in the inverse ratio of the permissible stress; for instance, if the unit stress is increased from 16,000 lb. per sq. in. for carbon steel to 24,000 lb. per sq. in. for high-tensile steel, or 50 per cent, the area of high-tensile steel required in tension will be two-thirds the area of carbon steel and the reduction in area and weight will be 33 per cent. However, the conditions will be quite different in a flat plate subjected to bending, as in a car floor. Here the strength varies as the square of the thickness and, if the thickness is reduced 33 per cent, the strength is reduced 55 per cent. In that case, the unit stress, instead of being 50 per cent more, would be increased 125 per cent. Because of this relationship, designers of high-tensile steel equipment have, in some cases, used corrugated or buckled sheets, or have reduced the unsupported area of flat panels.

Similar problems are encountered in the design of columns, girders and other elements of car structures. However, the basic principles for the proper application of the high-tensile materials have been developed and provide a sound basis for reliable and economical design.*

The protection of cars from corrosion deserves careful consideration, irrespective of the type of material used. Investigations have proved that atmospheric corrosion is chiefly responsible for the deterioration of railway equipment. Hence, in the selection of steel to withstand corrosion in cars, the most important factor is the resistance of the steel when exposed to the atmosphere. It is true that the most rapid corrosive attack occurs when destructive leachings are produced by coal or other commodities. None of the metals available for car construction offers adequate resistance to the action of contact corrosion under these conditions. Cars can be built to resist atmospheric corrosion and to give satisfactory life under normal service conditions, but it is impractical to design them to withstand the abuse which they sometimes receive when used as storage bins. However, every practical means should be adopted to protect freight cars by making them self-clearing and by eliminating laps and seams in which dirt and moisture may be retained. Marked improvement can often be made by minor changes, such as locating parts so that they will drain off an overlapping edge and not into a seam, or by welding to form an integral construction. Repairs necessary because of mechanical damage in present-day designs of freight cars have been reduced to a minimum; hence, attention to such details as are mentioned above is important to produce a similar increase in resistance to lading corrosion.

Forming Characteristics of High-Tensile Steels

From the standpoint of shop facilities, the introduction of high-tensile steels need cause little concern. Although these materials are stronger and therefore require more power than carbon steel when working with equal sizes, the thicknesses applied are usually decreased to such an extent that they can be formed and fabricated without exceeding the capacity of machines used for similar operations on carbon steel. It seems advisable to call attention to the fact that the manufacturer's rating for shop machinery is generally based on mild steel, and the maximum size for which a machine is rated will not apply to the stronger high-tensile steels. If machines are working near the limit of their capacity, it is advisable to give special attention to the condition of punches, dies and shear blades. Keeping tools sharp and in proper alinement will do much to prevent excessive loads.

In forming and fabricating high-tensile steels, it is always advisable to follow the instructions issued by the manufacturer. The variations from practices generally used for carbon steel may be slight; nevertheless, they may be responsible for the success or failure of the operation. When shops first undertake to work these materials, some important precautions are frequently overlooked, and it seems desirable to mention them here.

Pressed parts should be formed with somewhat larger radii than are commonly used with carbon steel. Some members which are ordinarily formed cold may need to be pressed hot when high-tensile steel is used. All parts made of high-tensile steel should be shaped to match closely before they are fastened together. It is not advisable to pull sections into place forcibly, because the material has considerably more spring-back than plain carbon steel and the structure is likely to be distorted due to trapped stresses. High-tensile steel will not compress in forming operations to the same extent as mild steel and will tend to fold over at pressed corners. To remedy this condition, the blank should not be cut in the normal manner on a radius to give a constant height of flange, but on a diagonal which will reduce the height of the flange at the corner. If preferred, a square notch may be cut out of the corner and the edges welded after pressing.

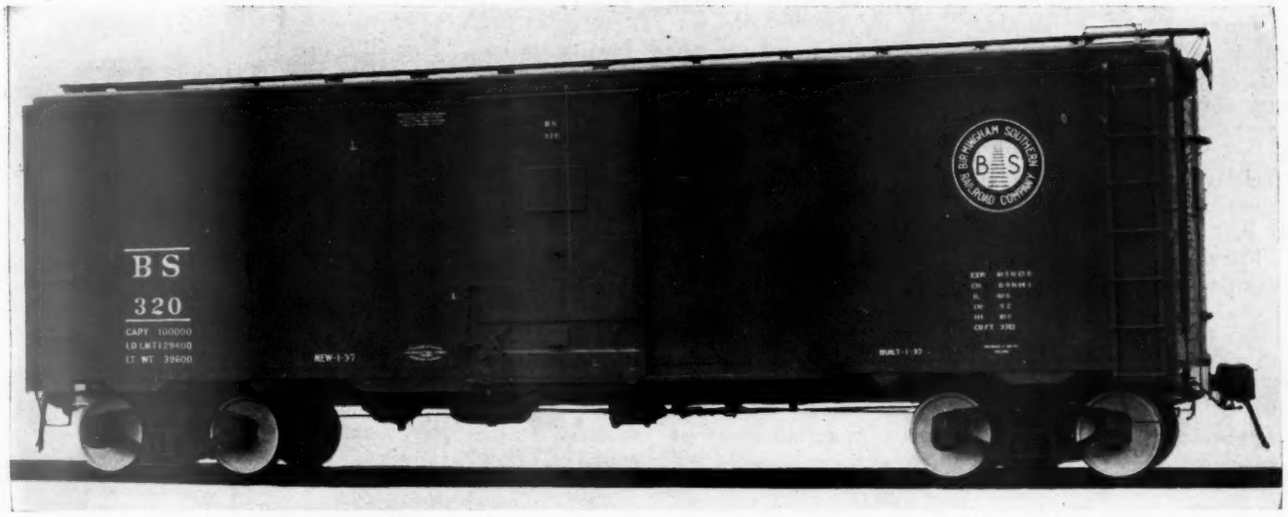
In working with high-tensile steel of low alloy content, proper control of temperature is generally more important than with carbon steel. It is advisable to avoid working either carbon steel or high-tensile steel at temperatures between 300 deg. and 1,000 deg. F. Furthermore, steel should not be held at temperatures within this range longer than necessary. Heating above the proper normalizing temperature for the particular steel in use should also be avoided.

Weldability Depends on Analysis of the Steel

The weldability of high-tensile steel is extremely important, because welded construction permits reduction in weight, and avoids overlapping seams and joints. It also obviates the necessity for the additional rivets required for thin sections, and thus lends itself to most effective and economical utilization of these materials in car equipment. The adaptability of the different compositions of high-tensile steels varies widely. Because of this, it is necessary to know that the particular material used in a welded structure is suitable for the process to be applied. For instance, the operation of spot welding consists of melting a small amount of the metal and then cooling it almost instantaneously through the critical temperatures. If the steel contains a considerable proportion of hardening elements, a region in or around the spot will be made hard and brittle by this process and the weld will have low resistance to shock and reversed stresses. The values of pressure, time and current giving the best results in spot welding are not the same for all steels. In a car structure, it is necessary to have welds possessing ample strength and endurance; therefore, the welding-machine setting should be adjusted for optimum results as determined by physical tests of specimens, and not merely for any combination of factors that will give a reasonably strong weld.

The methods of metallic arc welding used for high-tensile steels are ordinarily about the same as those used in welding carbon steels in connection with high-strength electrodes. It is unwise to use uncoated electrodes, which will deposit brittle metal of low strength. If this is done, the weld will be much the weakest part of the structure.

* See articles entitled Designing for High Tensile Steels, by H. M. Priest, published in the *Railway Mechanical Engineer*, May and June, 1936.



Welded underframes were used in 100 Cor-Ten box cars for the Birmingham Southern built by Pullman-Standard Car Manufacturing Co.

Where mild-steel electrodes are used for welding steel containing alloying elements, some of the melted base metal is mixed with the deposited metal, thereby increasing the strength of the weld. The extent to which mixing takes place depends on the type of joint, number of layers, and composition of the base metal. Due to this action, coated mild-steel electrodes often produce welds of satisfactory strength and excellent ductility. Such electrodes may be used except in some cases where the thickness of the weld cannot be more than that of the base metal and 100 per cent efficiency is required.

Fabricators have experienced some difficulty in avoiding buckling of the panels of welded high-tensile steel equipment. This trouble is due primarily to the thinness of the sheets, rather than to their added strength. Such buckling does not impair the strength of the equipment, but it detracts from a pleasing and workmanlike appearance. Careful designing will help the shop to avoid a wavy appearance in the sheets. An effective measure is to reduce the size of the panels, or they may be broken up into smaller sections by corrugations, which will also add stiffness. If neither of these methods is practicable, another alternative is to have every large smooth surface curved slightly.

Attention to minor details in the shop will help to insure satisfactory appearance in the finished car. The framework on which the sheets are supported should be in good alinement, with no irregularities in the surfaces to which the sheets are fastened. A slight wave or kink, which would not affect a heavy sheet, may cause a buckle in a thin sheet. In welding operations, distortion can best be prevented by tacking the sheet at some neutral point, and then working away from it in opposite directions.

Shop Practice Presents No Serious Difficulties

To avoid the impression that shop practice for high-tensile steel involves serious difficulties, it should be said that many fabricators have reported that such material gave no more trouble than mild steel. A good example of the satisfactory manner in which high-tensile steel has been applied is the case of the Victorian Railways of Australia. When this road first built a high-tensile-steel passenger train, no technicians familiar with the working of these materials were present and only general instructions regarding shop practice were available. The Chairman of the Victorian Railways reported:

"No difficulty whatever was experienced in the fabrication and assembly of the Cor-Ten-steel parts. The work has included welding, forming (hot and cold, but mainly cold), drilling, riveting, etc. Our experience was in accordance with the advice you gave us regarding the special allowance necessary for greater spring back, and this had already been taken care of in the design of the forming blocks.

"Shearing and riveting entailed no more difficulty than is normally experienced with commercial mild steel. Greater precision was, of course, required because of the lighter-gage material. Similarly electric arc welding by Cor-Ten electrodes did not present any difficulty."

Rebuilding with High-Tensile Steels

The accomplishments of the railroads and car builders, through the use of high-tensile steel for both new and rebuilt equipment, are noteworthy. You are, no doubt, familiar with much of the new equipment, but it may be of interest to describe briefly an ingenious method of increasing capacity adopted by one railroad. The hopper-car traffic on this road consists principally of coal, ore and coke. Because of the need of large cubic capacity for hauling coke, cars of 70 tons nominal capacity, 42 ft. long weighing 54,900 lb. and carrying 3,400 cu. ft., were assigned to this service. Another group of cars consisted of 520 50-ton hoppers, 32 ft. long having cubic capacity of 2,120 cu. ft. and weighing 41,000 lb.

Since the 70-ton cars, when loaded with coke, utilized only 65 per cent of the allowable weight capacity of the car and developed a total weight on rail of but 155,000 lb., a study was made to determine the feasibility of improving the ratio of pay load to tare weight by using high-tensile steel construction. As a result of this study, the railroad decided to rebuild the bodies of 520 70-ton cars, using corrosion-resistant high-tensile steel which would permit a substantial reduction in weight, and to mount these bodies on 50-ton trucks. The volume of the body was increased to 3,925 cu. ft., or 15.5 per cent, and the weight of the car was reduced to 41,900 lb. The ratio of pay load of coke to tare weight was increased from 1.82 to 2.92. The trucks required for these bodies were taken from the 520 hopper cars of 50 tons capacity. The bodies of the 50-ton cars were reinforced to provide sufficient strength for 70-ton loads, and were then mounted on the 70-ton trucks. In this

manner, the capacity of these cars for hauling ore was increased 17.6 per cent. Thus the rebuilding of the 520 cars was equivalent to adding 81 cars for coke and 143 cars for ore, yet the expenditure, including the added cost of the steel and labor, was only five per cent more per car than the cost of repairing in kind with copper steel, which would have left the cars unchanged and would not have afforded the benefits of increased capacity and more favorable load ratios.

The example cited above illustrates the possibilities of improvements to existing cars by applying high-tensile steels either in the complete car body or in individual parts. Frequently such changes can be made with resulting savings in interest, depreciation and maintenance, especially where, as in this case, the number of cars required to handle a given traffic can be decreased. In this instance, as in the majority of installations of high-tensile steel equipment, the operating aspects are most important. The largest saving produced by reconstructing these hopper cars is estimated to be the reduction in the net out-of-pocket cost of transportation. This again emphasizes the fact that the cost of hauling the dead weight of freight cars is usually greater than the cost of maintaining them. In all, the railroads spend annually over one and one-quarter billion dollars to provide and transport freight cars. This is an indication of the magnitude of the responsibility of the car-department officers, because these expenses are either directly determined, or largely influenced, by the types and characteristics of freight and passenger cars.

The producers of rolled steel introduced high-tensile materials, but it was necessary for the car builders and railroads to adapt them to light weight equipment as a means for improving the efficiency and economy of railroad transportation. The numerous and extensive installations of such equipment, only three years after the material which made them possible was introduced, are evidence of the initiative, resourcefulness and enterprise of the officers of the car department and the railroad organizations which they represent.

The Effect on Locomotive Boilers of

Pitting and Corrosion*

J. L. Callahan†

Results of corrosion-research experiments with feedwater of various analyses—The effect of alkalinity on corrosion discussed

A great deal has been written on the effect of alkalinity in boiler waters on corrosion. For the first time the results of a comprehensive series of experiments have been brought together for publication.

By alkalinity is meant the total carbonates and hydrates as obtained by titrating the water with an acid using methyl orange as the indicator. The prime purpose of adding alkalies to boiler feed water is to prevent the formation of hard scale so that most boiler waters carry alkalinity to some extent. Most feed waters have dissolved sulphates and chlorides, which concentrate in the boiler as dissolved salts. These salts together with the carbonates and hydrates and small amounts of other inorganic and organic matter constitute the dissolved solids. The dissolved solids are determined by evaporating a sample of boiler water and weighing the residue, or by using an electrical instrument.

There are several methods of expressing the alkalinity. The most common method is to state the total alkalinity as determined in the presence of the methyl orange indicator. Because of the difficulty of using methyl orange, other indicators are used. One of the easiest to use is phenolphthalein. However, this indicator will only show, in most cases, 85 to 95 per cent of the total alkalinity depending somewhat on the feed water used and the pressure. Others prefer to express the alkalinity as a percentage of the total dissolved solids. For example, if the total alkalinity was 20 and the total dissolved solids were 200, the per cent alkalinity would be 10.

Some excellent work has been done on corrosion, and one of the finest pieces of research was done by Commander Lyon for the Navy.** His general conclusions were (1) small amounts of alkali slightly retard corrosion, (2) increasing amounts increase corrosion until a maximum rate of corrosion takes place, and (3) further additions of alkalies decrease corrosion until at high concentrations of alkali no further corrosion takes place. Commander Lyons also found that all alkalies do not have the same effect.

With low chloride content he found that 50 grains per gal. of hydrated lime, 80 grains per gal. of soda ash, 61 grains per gal. of caustic soda, 110 grains per gal. of disodium phosphate, 13 grains per gal. of sodium chromate and 10 grains per gal. of sodium dichromate were required to stop corrosion. However, with more than 25 grains per gal. of sodium chloride present no amount of lime, chromates or dichromates would stop corrosion.

Commander Lyons also concluded that maximum corrosion occurred with 25 grains per gal. of soda ash or 19 grains per gal. of caustic soda, or 33 grains per gal. of disodium phosphate.

Experiences have differed on the effect of alkalinity. In many cases no corrosion or pitting has been experienced on railroads where alkalinities were maintained at a rather low value. In other cases railroads have had pitting at low and moderate alkalinities, and in some cases it has been found that excessively high alkalinities are required to prevent pitting. Because of these varied experience several series of experiments were conducted to find the effect of alkalinity.

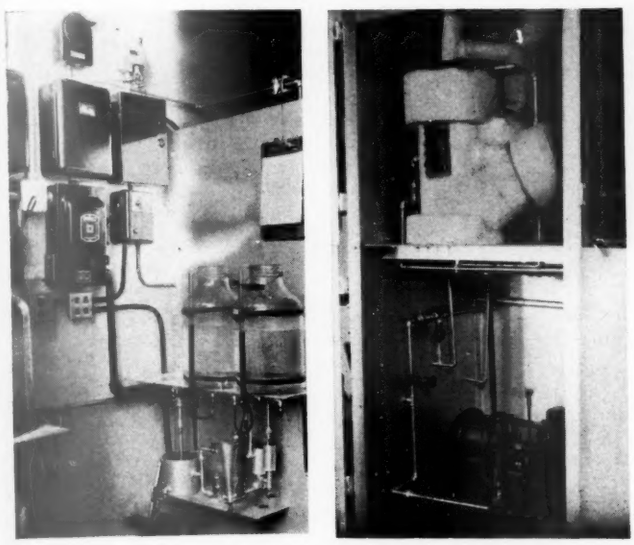
* Presented at the Convention of the Master Boiler Makers' Association held in Chicago, Wednesday, September 29, 1937.

† Service Engineer, National Aluminate Corporation.

** "Corrosion of Boilers and of Piping on Ship Board," by Commander Frank Lyon, Journal of the American Society of Naval Engineers," vol. 24, 1912, p. 845.

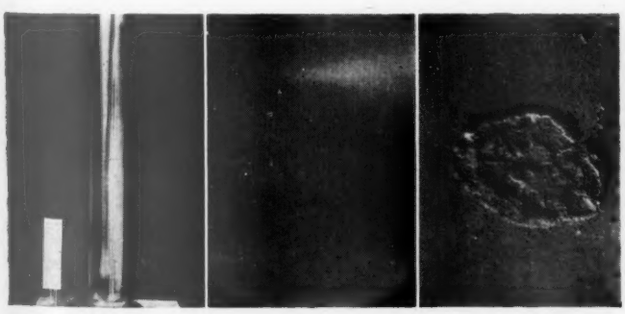
The tests were made in boilers operating at 250 lb. per. sq. in., using feedwater at the rate of 1 gal. per hr.

The experimental boilers hold 0.8 gal. at normal water level. Each consists of a vertical drum to which is attached the external heating section and return circulation tube. The heat is supplied by a suitable electrical heating element placed inside a boiler tube 12 in. long, which in turn is held securely inside the heating section.



Test apparatus. Left: Boiler and feed pump. Right: Feedwater storage and controls

A boiler tube can be withdrawn and inspected for scale and corrosion at the end of a test as the outside of the boiler tube is the water side, corresponding to a fire tube. The heating section and boiler tube are inclined upward from the bottom of the drum at an angle of 30 deg. from horizontal. The circulation tube returns steam and water from the upper point of the heating section to the drum. By this means circulation of boiler water is obtained. The feedwater enters just below the waterline. Blowdown is taken 2 in. below the surface.



Left: Boiler tube ready for use. Center: Surface of clean boiler tube. Right: Tube corrosion with Alkalinity = 20, dissolved solids = 103

These boilers are operated by automatic devices which control the feedwater pumps, pressure, preheater temperature, blowdown rate, and evaporation rate at any setting desired.

The feedwater in all cases carried over 5 cc per liter of oxygen and was not preheated. In order to eliminate experimental errors while the boiler water was building up to concentration, the tests were made on boiler water which was carefully preconcentrated to the desired value.

These tubes were made of standard 10-20 class A boiler-tube steel by welding a flange at one end and a plug in the other end, after which mill scale was removed by grinding with a final working of medium emery paper.

There are a great many factors which influence corrosion, but the purpose of this whole investigation was to find the effect of alkalinity alone when no other factors such as scale, organic matter, protected surfaces, or oxygen absorbents would interfere.

The first series of tests was made using a feedwater having the analysis of hardness = 0.0, total alkalinity = 3.2, chlorides = 4.3, sulphates = 8.5 and oxygen = 5.5 cc per liter. This feedwater was chosen as being similar to water where corrosion was being experienced.

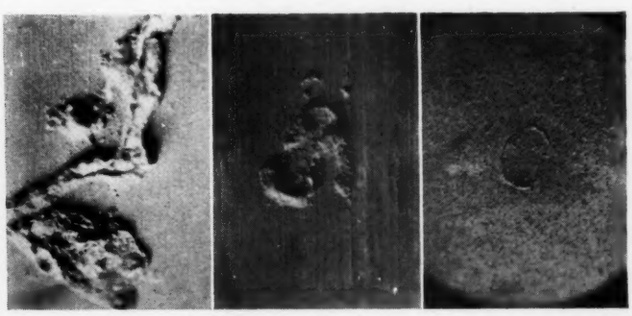
Table I—First Series of Corrosion-Research Experiments

Boiler Water Analysis						
H	P	M	Cl	SO_4	D.S.	Remarks
0.0	8.9	10.9	13.1	22	48	Considerable general corrosion and some pitting
0.0	18.0	20.0	28.0	54	103	Considerable general corrosion and pitting
0.0	33.0	36.0	44.0	83	161	Considerable general corrosion and some pitting
0.0	43.0	46.0	59.0	112	221	Considerable general corrosion and some pitting
0.0	53.0	57.0	83.0	164	318	Some general corrosion and some pitting
0.0	58.0	64.0	88.0	174	325	Some general corrosion and considerable pitting
0.0	67.0	69.0	100.0	193	371	Considerable general corrosion and pitting
0.0	73.0	81.0	110.0	203	406	Considerable general corrosion and some pitting
0.0	82.0	89.0	122.0	234	448	Some general corrosion and pitting
0.0	95.0	104.0	141.0	272	522	Some general corrosion and pitting

A feedwater alkalinity of 3.2 was used as this resulted in a boiler water having an alkalinity approximately 20 per cent of the dissolved solids.

Tests were made at ten different concentrations, with analyses and dissolved solids varying between 48 and 522 grains per gal., as given in Table I, in order to cover as wide a range of conditions as possible.

The general conclusions of this series of tests are (1) that an alkalinity of 20 per cent of the dissolved solids does not prevent corrosion, (2) that at low concentrations general red corrosion predominated, and (3) that at high concentrations pitting predominated.



Tube corrosion. Left: Alkalinity = 46, dissolved solids = 221. Center: Alkalinity = 104, dissolved solids = 522. Right: Alkalinity = 10.4, dissolved solids = 111

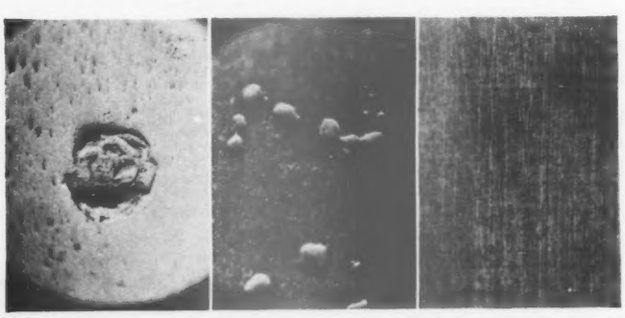
The question then arose as to whether or not any amount of alkalinity would stop corrosion. To answer this question a second series of nine experiments was made with feedwater analyses and total dissolved solids in the neighborhood of 135 grains per gal., as given in Table II, and with the amount of alkalinity in the boiler

water varying between 5 and 90 grains per gal. The feedwater analysis was chlorides = 4.3, sulphates = 8.5 and oxygen = 5.5 cc per liter as in the previous series of tests, but in which the alkalinity was adjusted to get the desired alkalinity in the boiler water.

Table II—Second Series of Corrosion-Research Experiments

Boiler Water Analysis						Remarks
H	P	M	Cl	CO_4	D.S.	
0.0	3.1	5.1	49.9	91	155	Heavy general corrosion and pitting
0.0	7.5	10.4	35.3	63	111	Considerable general corrosion and pitting
0.0	17.3	20.9	31.2	60	119	Decrease in general corrosion, increase in pitting
0.0	27.5	32.7	38.2	69	144	Decrease in general corrosion, increased pitting
0.0	35.8	40.8	27.2	54	125	Further decrease in general corrosion, pitting greatly reduced
0.0	49.9	54.0	26.0	57	134	Little general corrosion, some pitting
0.0	64.0	71.0	20.5	42	139	Very little general corrosion or pitting
0.0	77.0	85.0	17.0	36	143	No pitting
0.0	83.0	90.0	17.0	29	140	No pitting

The general conclusions from these experiments are



Tube corrosion. Left: Alkalinity = 20.9, dissolved solids = 119. Center: Alkalinity = 54, dissolved solids = 134. Right: Alkalinity = 71, dissolved solids = 139

(1) that corrosion and pitting will be prevented if sufficiently high alkalinity is carried, (2) that the addition of alkalinity tends to convert general red corrosion into pitting, and (3) that alkalinity will prevent general corrosion before it will prevent pitting.

With alkalinity of 85 and dissolved solids of 143 there was no corrosion or pitting. Good results were also obtained with an alkalinity of 71 and dissolved solids of 139.

These two series of tests brought out a number of interesting points, but it was felt that the investigation should be broadened to determine the amount of alkalinity required over a wide range of conditions.

Further experiments were carried out much in the same manner as the previous experiments. The feedwater analysis was chlorides = 4.3, sulphates = 8.5, and oxygen = 5.5 cc per liter. In addition, sodium carbonate and caustic soda were added in equal parts to maintain the desired alkalinity in the feedwater.

This group of experiments consisted of six series. In each series the amount of chlorides and sulphates in the boiler water was held constant. The boiler water alkalinity was low in the first experiment of each series, and raised gradually with each succeeding experiment until more than enough alkalinity had been added to stop pitting. The results were consistent throughout, but each series of experiments was run twice in that portion considered to be the critical range, for complete protection.

One very interesting observation made was that in tests with low alkalinity the tubes were always red. As the alkalinity was increased the red corrosion gradually disappeared, the tube becoming darker and, in many cases, almost jet black. However, pitting persisted until sufficient alkalinity had been added. Those tubes on which corrosion could be found were covered with a jet-black film which was smooth and hard. This film was very thin and served to protect these tubes from atmospheric corrosion. This region is called the critical range.

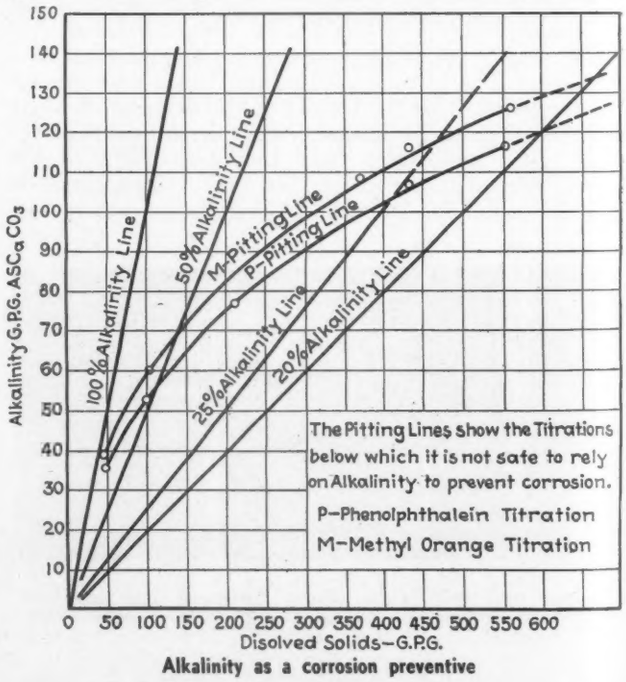
The information obtained from the last experiments would justify the additional conclusions (1) that excessive alkalinity is required to be sure that corrosion does not take place, (2) that as the dissolved solids increase the amount of alkalinity required increases, and (3) that the percentage of alkalinity required is less with high dissolved solids than with low dissolved solids.

The general conclusions obtained from these investigations, as given in Table III, agree with the findings of Commander Lyons, except that our observations do not justify the conclusion that there is a maximum corrosion rate at alkalinities of 19 to 25 grains per gal.

Table III—Conclusions of Corrosion-Research Experiments

Dissolved Saline Salts, Grains per Gal.	Alkalinity, Grains per Gal.	
	Corroding	Non-Corroding
0	36	39
40	58	61
125	78	84
260	104	108
310	106	116
420	118	126

This may be explained on the basis that our tests were made without scale-forming substances present, whereas with scale-forming substances present less corrosion is to be expected at low alkalinity where the tubes will be covered with scale than at higher alkalinities where the tubes will not be so well protected by scale.


Alkalinity G.P.G. As $CaCO_3$
Disolved Solids—G.P.G.
100% Alkalinity Line
50% Alkalinity Line
25% Alkalinity Line
20% Alkalinity Line
M-Pitting Line
P-Pitting Line
The Pitting Lines show the Titrations below which it is not safe to rely on Alkalinity to prevent corrosion.
P—Phenolphthalein Titration
M—Methyl Orange Titration

Alkalinity as a corrosion preventive

Field observations have tended to substantiate the findings presented here.

The author acknowledges the cooperation of Dr. P. G. Bird, Research Director of the National Aluminate Corporation, under whose direction these experiments were conducted.

Factors Influencing the

Future of Transportation*

By L. K. Sillcox†

Experience of past interpreted in relation to modern conditions—The direction of future railway expansion discussed

We have come to be a nation whose industrial enterprise, and every department of national solidarity and national life are so closely associated with transportation that the two are vitally interdependent. In the past twenty years, and particularly during the past decade, we have witnessed a remarkable change—one which has been of real benefit to the nation but scarcely so to the railways. Competition has arisen and projected itself into the business of transport with no rational plan and, for the most part, with no responsible guidance. The result has been a tremendous transport upheaval, with competitors striving to broaden the wedge which has been driven ever deeper into an expanding traffic volume and the railways fighting to arrest the trend with every familiar weapon.

The private automobile and truck on the highway have been most active in creating this transport revolution. The railways, with the experiences of the recent past freshly in mind, can ill afford to permit the airway a strong foothold, without challenge, on so much as the fringe of mass transport.

New Standards of Speed and Comfort

The public has been educated to expect that which it demands and it will be served. Forty and fifty years ago the railways demonstrated their capacity for high speed passenger service yet it is, for the most part, isolated runs which are recorded.

From this time forward we may look to no new accomplishments in speed which will not be widely patronized and progress in one territory must be immediately simulated in every other. The railways must provide these accommodations or surrender the traffic. With the general taste for speed comes the present clamor for comfort—comfort in freedom from jolts and bad starts—comfort in temperature and humidity—comfort in deep and restful upholstery of well proportioned seats—eye comfort in the coloring of interior decoration and well directed lighting—and comfort in stopping from whatever high speed may be operated in a distance which is consistent at once with high scheduled speed, the ultimate accomplishment in safety, and comfort.

Given the best of modern tools with which to work, the engineman at the throttle and brake valve and his supervisors are the men who bear responsibility of maintaining railway standards of passenger comfort. Colors and fixtures are inert appointments which are or are not acceptable when the car is released. Air conditioning must be automatically adapted to the average taste before it can be considered fully developed. But a locomotive and its train constitute a live and dynamic entity, responding to the expert hand of the man in the cab and the value of all fine appointments are forfeited if he is either careless or has not received the careful training which is essential for the complete understanding of the equipment he controls. This knowledge of function and operation are indispensable to the proper and economical performance of his duty.

It must not be supposed that ultra-high speed trains will not show economic justification. It has been increasingly realized, during the past few years, that the railways possess a valuable asset in being able to offer high-speed transport combined with an exceptional degree of safety and reliability. Record performances of air travel, racing automobiles, and ocean-going liners have all had a profound influence on design; and it is beyond dispute that the movement towards considerably higher speeds on railways has not only resulted in increased capacity for sustained high speed, but has advanced thermal efficiency at the same time to such a degree as will ultimately benefit all classes of locomotives similarly and the psychological effect on railway personnel of the presence on the line of these high-speed trains is considerable. The fact that they must not in any circumstances, be delayed, smartens up the handling of all train movements, the irregular or more indifferent treatment of which might react upon the new services.

The spectacular in railway achievement, such as the appearance, the speed, and the comfort of these newer trains, cannot be despised in the influence that it exercises on the mind of the public. Public patronage is, after all, the only sure element on which these developments of railway enterprise can be built, and we are certain that newer high-speed service of the character now being offered, in the attention that it directs to the combination of speed, safety and comfort afforded by modern railway travel, will prove to be well worth the cost and effort it involves.

A New Basis for Rates Needed

There is also to be considered the recurrent demand for railway freight rate and passenger fare reductions—scarcely compatible with increasing costs but none-theless real and requiring the efficient accomplishment of the ultimate in operating economies. Since the railway transition from a monopolistic to a highly competitive industry in the last twenty years, dependence upon a level of popular rates and an appealing character of service has been emphasized.

The railway rate question steadily has grown more involved in its relation to the balance of transport values with each step in the broadening field of transport competition until the intricacies of the problem itself now challenge the complexities of the railway rate structure. Whereas it has been possible, for many years, to adjust railway rates to the value of the commodities to which they apply, thereby enforcing a reasonable relationship between cost to the shipper and value of the service, the motor truck on the highway has quite effectively distorted this relationship. The value of transport to all shippers has become the least cost for which it can be obtained and, where the highway hauler is

* Presented at the Convention of Railway Fuel and Traveling Engineers' Association, held in Chicago, Thursday, September 30, 1937.

† First Vice-President, New York Air Brake Company.

concerned, the rate which he quotes generally bears some definite relationship to the actual cost of the movement.

"What the traffic will bear," a rate making basis of sound economic background in monopoly, can maintain neither its definition nor justification in competition. Railway costs are not easily assigned but they unquestionably constitute a tariff base which must be respected if competitors are not inclined to adopt the railway plan of rate making. The cost of transport by railway can be assigned on some reasonable basis more readily, probably, than as complete a class rate structure for highway operations, embodying all the involved detail of the railway system, could be built up and enforced. The railway rates could never be applied to highway operations with a fixed differential favorable to the highway operations, expecting the motor truck to provide the universal service performed by railway. The motor truck presents a new problem in its general incompetence. Its methods are the more simple and thus, the more readily adaptable to railway use.

Present Trends Influenced by Early Experience

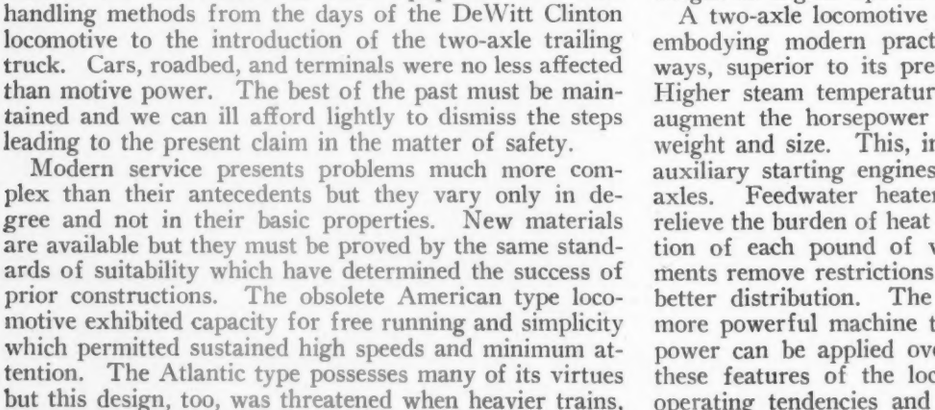
A great deal of diligent study and experimentation marked the innovations in train equipment and train handling methods from the days of the DeWitt Clinton locomotive to the introduction of the two-axle trailing truck. Cars, roadbed, and terminals were no less affected than motive power. The best of the past must be maintained and we can ill afford lightly to dismiss the steps leading to the present claim in the matter of safety.

Modern service presents problems much more complex than their antecedents but they vary only in degree and not in their basic properties. New materials are available but they must be proved by the same standards of suitability which have determined the success of prior constructions. The obsolete American type locomotive exhibited capacity for free running and simplicity which permitted sustained high speeds and minimum attention. The Atlantic type possesses many of its virtues but this design, too, was threatened when heavier trains, resulting more from increased weight per passenger than from greater revenue load carried, were substituted for those which two driving axles could smoothly set in motion. But early railway history taught the desirability of limiting the number of driving axles and railway mechanical officers have not forgotten their early experiences but have reluctantly added axles to main-line passenger motive power to provide the adhesion which trends in train consist compelled.

There is now observed a movement toward the simplified types. Two-driving-axle locomotives, with trailing trucks which are sometimes power equipped, are being built for important passenger runs for the first time in many years. The Mountain type locomotive for passenger work may respond to changes by articulated designs of four driving axles for extremely heavy, fast passenger service, breaking up the rigid wheelbase into two distinct units and duplicating cylinders to retain the high-speed mechanical potentialities of the early American type. Beyond the desire to regain the benefits which the past has demonstrated as accruing from the twin-axle drive are found tendencies in train consist and service permitting fewer axles to meet modern adhesion requirements. The horsepower peak must be developed at higher speed to give economical high-speed performance. Since horsepower is defined as the rate of performing work and is expressed in terms of foot pounds per second, the higher the speed, the lower must be the pounds to be overcome for a given horsepower output, fixed by boiler evaporative capacity. This relationship fixes permissible tonnage at high speed and it is further affected since the pounds factor in the equation relates to train resistance and this, in turn, increases with respect to weight as higher speeds are operated.

A two-axle locomotive can, moreover, be constructed, embodying modern practices, which will be, in many ways, superior to its predecessor of twenty years ago. Higher steam temperatures and higher boiler pressures augment the horsepower capacity of a boiler of given weight and size. This, in turn makes it possible to use auxiliary starting engines successfully on formerly idle axles. Feedwater heaters or exhaust-steam injectors relieve the burden of heat input required for the evaporation of each pound of water while valve gear refinements remove restrictions to the steam flow and provide better distribution. The lighter locomotive is a much more powerful machine than heretofore and its greater power can be applied over a much longer period. All these features of the locomotive itself, combined with operating tendencies and advance in car-building practices, are assisting toward the return of the lighter designs and recovering some of the advantages which the past has shown to be attendant upon simplicity in construction, light-weight pistons, rods and crossheads, and short rigid wheelbases.

Passenger cars were progressively strengthened through the years in response to public insistence for protection against the horrors of early train accidents. This was accomplished by adding greatly to their weight. Vestibules, non-telescoping car ends, and steel construc-



". . . the railways possess a valuable asset in being able to offer high-speed transport combined with an exceptional degree of safety and reliability"

"The train-service staff shares responsibility with railway management"

tion throughout were successively adopted, increasing the weight of the 50-ft. 50,000-lb. coach of 1860 to anywhere from 130,000 to 160,000 lb. for the equivalent, conventional 70-ft. coach or chair car of the present day. Limiting values of wheel and axle loading, consistent with the speeds and services of the past, have been determined and passed on to us for our guidance. Six-wheel trucks under passenger cars appeared in 1876, long before car weight reached the level of steel construction. Car riding qualities were improved by the change while wheel loads were reduced to nominal values.

It is no longer necessary to adhere to massive construction to achieve the essential degree of security for passengers. The lightest of the modern cars of standard size weighs from 100,000 to 115,000 lb. Refinements in truck design have shown the way to passenger comfort without resorting to six-wheels and articulated construction,

Advantage has been taken of all these advances in the art of car building with too little regard for the burden imposed on wheels and axles. The car wheel of today is admittedly superior to that of 1900 but resistance to wheel defects has been unable to keep pace with the increased rigors of the service to which it is subjected. Confidence in our ability to meet modern demands with modern materials, has perhaps, resulted in our unjustifiably ignoring the conditions which accounted for relative freedom from the wheel defects and axle and bearing failures in the past. These have multiplied coincidentally with the simultaneous adoption of high wheel loads and greatly increased speeds.

So long as trains were operated under similar conditions throughout the country, it was sufficient to assign a maximum static loading upon a wheel-and-axle assembly of given journal dimension, particularly since this loading value had been determined by experience in observing the loads under which axle failures were or were not recurrent. A static load limit was thus no more than an index of capacity rather than a specification of stress to which the axle would be subjected and, so long as the speed operated did not exceed a common conventional maximum and elasticity of the track was uniform, the dynamic loading bore a relation to the static figure which was substantially constant.

The basic limiting static loads, first selected by the Master Car Builders' Association, were applicable to wheel and axle assemblies installed under freight cars. Since the dynamic effects at higher speed were known to impose more severe duty in passenger service than in freight, despite the improved spring suspension systems employed in the former, the various railways and car owners arbitrarily selected modifying ratios of permissible loading when wheels and axles were installed under passenger-train cars. These ratios varied from 70 to 85 per cent of the freight values. It is significant that those administrations which adopted the lower unit loading have been more successful in meeting the modern tendency toward universally higher speed than those who were less conservative.

Direction of Future Railway Expansion

There is a decline in railway mileage and a further decline will be observed and should be invited on the grounds of economy and appreciating net revenue. The railways of our country embrace approximately one-quarter of a million miles of track of which probably ten to twenty per cent should be abandoned as no longer economically justified. Half the traffic is concentrated on about 22,000 miles of line, or less than ten per cent of the whole. The administrations operating the remainder have to survive as best they can on such profits as may be derived from handling the other half of the traffic.

The average ton miles of freight hauled per capita has increased approximately three and one-half times since the figure of 1,280 ton miles was recorded in 1890. This is due at once to the greater availability of commodities originating at points remote from the regions of consumption, and to the demand for more merchandise per capita, following upon a higher national standard of living and greater value represented by the transport service performed. The railways alone are accountable for the former and they have contributed generously to the latter. As long as there were new territories to be opened and new reservoirs of natural resources to be tapped, enlargement of transport activities was automatically encouraged and its direction was specified. The railway burden was that of providing the facilities which would satisfy the transport demand and, if the service were available, patronage was assured no matter what the type of service might be.

Further growth must follow a demand which the railways themselves create in competition with agencies which operate independently of railway management. More diligent and strenuous effort must be expended in maintaining the economic status and prestige of the industry under these conditions and the success of the expansion program is no longer solely related to the capacities of locomotives, cars and rails but it is the direct responsibility of railway officers and men, to be personally achieved. The train-service staff shares the responsibility with railway management since the formulating of policies would be thoroughly incompetent under existing conditions without the full support of these in whose hands the economical administration of these policies must rest.

In common with many other branches of railway service, the offices of road foremen have been charged with duties which are much more complex and exacting than those common to them in the past. Each mechanical detail of the equipment that they supervise presents

new problems through refinement of detail. Road enginemen and firemen must be highly trained specialists, equipped with that store of knowledge and sincere loyalty which insures proper care of a costly mechanism, the nurturing of an increasingly sympathetic attitude on the part of the railway patron, and consistent economical and precise conformity with difficult schedules. The road foreman must be a man of varied capabilities, free to educate, free to plan, free to supervise, free to analyze. His duties are not confined to the cab and his competence is not measured by the number of unusual but effective schemes of manipulation which he devises, sometimes grossly in error. The modern traveling engineer is truly an administrator of the service who will not permit the enforcement of an unnecessary speed restriction and who will weigh, without prejudice, the value of mechanical changes which are recommended to apply to the locomotives under his supervision.

Brake Shoes and Signals

It is only in the recent past, in fact with the introduction of the Diesel-electric streamlined trains, that it has been necessary to depart from the standard brake shoe dimensions, 3⅜ in. by 13¾ in. which has been nationally used in both freight and passenger service for both 33-in. and 36-in. wheels. The necessity for change has been occasioned by greatly increased braking ratios. Always higher in passenger service (90 per cent in full service, 60 lb. brake-cylinder pressure; or 150 per cent in emergency, 100 lb. brake-cylinder pressure), the new trains have adopted values ranging from 160 to 270 per cent braking ratio corresponding to 100 lb. brake-cylinder pressure. So great has become the concentration of pressure upon brake shoes when installed in accordance with familiar practice that their contact faces rapidly disintegrate and their effectiveness is diminished.

Two schemes have been employed to relieve this undue pressure. First, the brake heads have been so constructed as to accommodate two shoes per head, the shoe length being modified to adjust the braking surface to actual requirements. The other plan requires a single long brake shoe affording increased contact area. Provided the shoe area is the same in either case, it apparently matters little whether the shoe is cast in one or two parts. Insufficient data are available to warrant definite and well founded recommendations. The single long shoe breaks in the approximate center immediately upon the first heavy brake application and is thereafter allowed some measure of freedom in adjusting itself to the wheel tread as the double shoe is permitted to do upon application. Brake-shoe laboratory dynamometer tests show a slight apparent increase in the average coefficient of brake-shoe friction from high speed favoring the long shoe. The interrupted face of the double-shoe design effectively breaks up the spark stream and is subject to less warping. The long shoe is much heavier to handle; the double shoe requires double keying. Both designs serve satisfactorily in service and there is no unified opinion which accepts either to the exclusion of the other.

The special object of the elaborate modern system of main-line signaling and control is to enable each train to run over the line with as high a degree of safety as it would enjoy were it the only train on the track as long as the signals show a clear right of way and except as restrained by them. If signals are not visible, no speed is safe; if clearly visible at all times, any speed is safe in so far as the hazard of collision is concerned, provided the brake equipment and signal spacing are so coordinated that a stop within the distance controlled by a signal is assured. Signals should then be clearly visible and automatically responsive. The brake should be of such capacity that there can be no question with respect to the ability of the engineman to stop within the distance of track which the signal shows to be unoccupied.

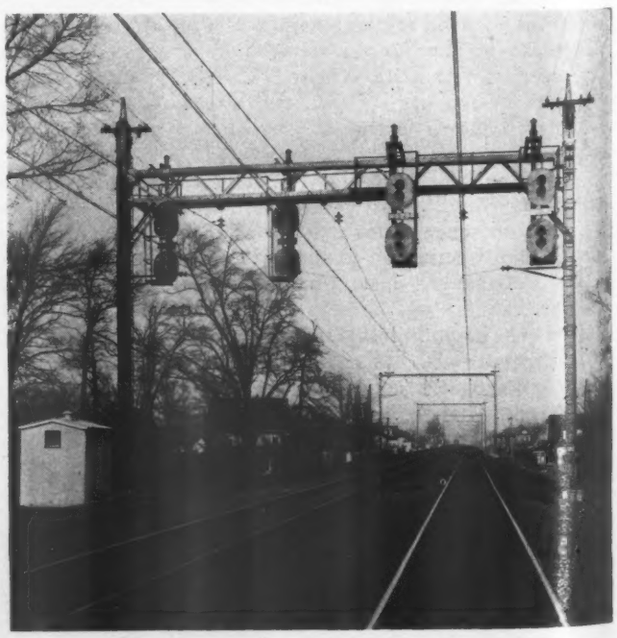
The greater the signal spacing, the greater is the road delay whenever signals display other than clear indications. This delay is greatest and most costly for the slower movements but affects all trains. For scheduled movements, all such delays either interfere with on-time performance or require higher top speeds during the remainder of the run. To avoid costly respacing of signals for high-speed services, with the equally costly delay which follows, brake equipment types of increased capacity are required when the highest current speeds are to be exceeded.

High Speeds Call for New Brakes

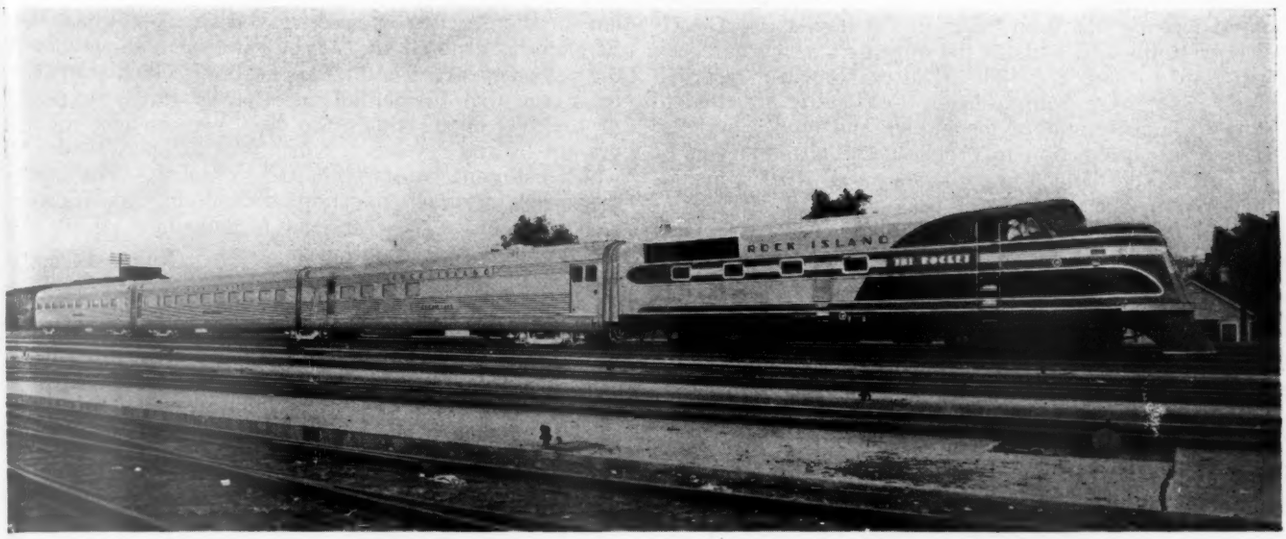
A great part of the railway signaling system in this country has been laid out to conform with service stopping distances and 60 m.p.h. speeds. Each brake type is fortified by an emergency feature whereby the 60 m.p.h. service stopping distance need not be exceeded by trains operating at moderately higher speeds. Infrequently used, the emergency capacity is always available to enginemen should conditions require a minimum stop within fixed signal spacing.

New conditions are now presented. Modern main-line passenger trains are no longer moderately in excess of 60 m.p.h. In some territories they have almost doubled this figure and this has called for complex and costly signal arrangements where the conventional brake has been retained. Other administrations have utilized the brake types which offer the greatest capacity and most varied capabilities, adopting the plan which not only permanently equips the high-speed trains for high-speed service in whatever territory they may operate, but conserves the high cost of sacrificing flexibility in the operation of all trains, fast and slow, on the one hand, and forestalls the necessity for spending vast sums for costly addition of aspects on the other.

The action of a perfect brake would duplicate the retardation impressed by the force of gravity were an



"The special object of the elaborate modern system of main-line signaling and control is to enable each train to run over the line with as high a degree of safety as it would enjoy were it the only train on the track



One of six Rocket Diesel-driven trains placed in service on the Chicago, Rock Island & Pacific

ascending incline with suitable gradual approach suddenly presented in front of a train to arrest its motion. An ascending grade affects each pound of train weight in the same manner. To produce this effect, there should be no delay in securing the retarding force when the brake application is initiated. This is accomplished by electric propagation of the brake impulse in the HSC brake schedule, the latest design of passenger-car brake equipment and the one installed in the most modern high-speed train equipment. The rate of brake-cylinder-pressure build up, which corresponds to the gradual approach to our hypothetical slope is adjusted to attain the maximum retardation effect at the fastest rate consistent with comfort of passengers. In emergency applications the ideal comfort consideration is sacrificed for stopping distance and a pronounced retardation effect is felt as the brakes are applied.

There remains to be considered the rise of the slope with which the ideal brake should compare. If the speed were sufficiently high and the grade progressively steeper as the train proceeded to a stop, the full force of gravity, represented by a vertical ascent, could be utilized. Wheel sliding would not be a factor. In the retardation of trains by pressing brake shoes against wheel treads, the limiting rate of retardation is fixed by adhesion at the rails. All of the evidence that has been collected indicates that adhesion values are practically constant as long as wheels rotate without slippage and the coefficient of adhesion approaches or attains its static value. This value is, of course, variable with rail conditions.

Will Balanced Braking Become Effective?

A constant retarding force will produce a constant retardation rate. This is highly desirable in effecting emergency stops of minimum length. A constant brake-shoe pressure will not assure a constant braking force because, under such circumstances, the retarding force would follow each variation in the coefficient of brake-shoe friction and if the retardation rate were to approach the limit of wheel sliding at high and moderate speeds, destructive sliding would occur in the low-speed range. In recognition of the desirability of limiting the retarding force to that which will not cause wheel sliding, the Decelakron was developed and is used in conjunction with the HSC brake to police the retardation rate during heavy brake applications.

Directly and delicately responsive to the rate of retardation, the Decelakron functions to reduce brake-cylinder pressure as the rate of retardation approaches the point of wheel sliding. Although a rate of 3.5 m.p.h. per sec. should be a conservative specification, insofar as the limitation of wheel-rail adhesions are concerned, it has not been found possible to attain this high rate satisfactorily with trains yet constructed for the reason that the relation between retarding force and weight supported has not been reasonably uniform in each of the trucks in the train and braking ratios have not been sufficiently high to impress this rate in conjunction with the low coefficient of brake-shoe friction at high speed. Consequently, were a retardation rate of 3.5 miles per hour per second to be obtained with existing equipment as now braked, it would be required that some wheels and some trucks be braked to retard at a much higher rate with the probability that wheel sliding would occur. This too is a grave defect in the attempt to secure high rates of retardation with the more conventional types of passenger trains hauled by steam locomotives, particularly in cases where new trains, embodying light-weight cars, are involved. Slack action, when permitted to assume any high value, aggravates the condition.

The installation of the HSC brake, embodying the Decelakron, could not assist in such circumstances. It is quite natural that the greater the proportion of total train weight represented by the locomotive, the greater will be its effect in prolonging the stop. When light-weight cars with correspondingly light unit brake-shoe pressure are included in the train consist, the moderate shoe pressure provides the high coefficient of brake-shoe friction which still further unbalances retardation forces with respect to the weight supported. As long as a uniform braking ratio is specified for all passenger-train cars to be employed in connectional services, those cars which present the lightest wheel loads will be actually braked at a higher level and will, therefore, be especially susceptible to wheel sliding. Introduce slack action, which momentarily reduces speed and permits the coefficient of brake-shoe friction, to assume a high value approaching a static condition, or an uneven and rigid track surface, such as that characteristic of a frozen roadbed and the destructive sliding of wheels is certain to result.

The time has come when the specification of a "standard" braking ratio is not enough. Attempt toward bal-

anced braking has been made in the high-speed Diesel-electric trains and without the approach which has been witnessed to date, the high brake performance recorded could never have been realized. No one is prepared to state the upper limit of locomotive and tender braking. It is a safe prediction to prophesy the abandonment of the use of full-flanged brake shoes on all wheels, including drivers, but the level of braking which can be impressed on steel-tired wheels is unknown. An experimental progressive increase is desirable and necessary if this type of motive power is to compete successfully with the low-wheel, Diesel-electric power unit and display the same degree of safety as measured in terms of stopping distance.

New Attitudes Needed

Despite our predictions that the future of transport is revealed to us, that things to come can be foretold with reasonable accuracy, we must, of course, continue to watch with intelligence for the unfolding of our prophecies—still more for the startling and spectacular developments of which we are assured and which must necessarily invigorate our every thought and action. A single record shattered hastens the day when our projected plans are realized and translated into daily procedure. We are truly in doubt with respect to the time of accomplishment

Marked advance in transport speed awaits new attitudes in this vast industry. It is no less true today than in the first of the nineteenth century when steam ushered in its first remarkable change. Faster travel was then the result of chance discovery. Today, many men are actively engaged in serious study of further improvement which will satisfy a demand which was not insistent when Newcomen, Watt, Trevithick and Stephenson aroused the world with their researches in the power of steam and its application to land transport. It is true that further advance hardly can be expected to multiply many times the best performance of the present by any revelation which will, at once, render all which has gone before completely obsolete. The higher the speeds attained, the more difficult further improvement becomes. A great deal is demanded of us and the people of our country will be served.

Without vast mechanical achievements there could be no progress as we know it. Transport would be restricted as in the days of the Caesars. But power alone can never build an industry. The enlargement of our great railway system was, at the time of its greatest activity, fifty years ago, a capital transaction in human affairs; as such it has kept its place in history—as such it will maintain itself while this nation is commercially and socially prosperous. The scene and the actors have owed nothing to dramatic effects for their profound influence upon the nation. The worth and the force rest wholly in the wisdom, the courage, and the faith they displayed.

The cardinal elements which enter into the value of so great an enterprise are few and by no means recondite. The infinite variety of discordant elements of temporary significance are often less clearly discernible. It is often easier to map the path of transport progress over a period of years, paralleling and keeping pace with social advance, than to trace its intermediate deviations. The vision of the farthest goal which we can conceive must be constantly before us if we are not to be misled in the direction of current forces. There are no casual tasks in railway service if the traditions which we have inherited are to be preserved.

Status of Condensing and

Steam-Turbine Locomotives*

By L. P. Michael†

Report of Railway Fuel and Traveling Engineers' Association includes a description of a condensing steam-turbine locomotive with mechanical transmission

There are, as nearly as can be determined from latest reports, four steam turbine-driven locomotives in road service. Three of these locomotives are being operated in Sweden and one in England. They were all built under the Ljungstrom patents and are of the non-condensing type. The general design is practically the same as for the standard reciprocating locomotives in the countries in which they are being used except that the steam cylinders are replaced by a steam turbine having its shaft at right angles to the longitudinal center line of the locomotive.

This turbine shaft is fitted with a pinion which drives, either direct or through an intermediate gear, a main gear on a jack shaft which extends across the front of the locomotive, under the smokebox.

The direct drive, (pinion to main gear) drives the locomotive in one direction, and the drive from the pinion through the intermediate gear to the main gear drives the locomotive in the opposite direction.

Discs are located on the ends of the jack shaft and are spaced laterally the same distance apart as the driving wheels on the locomotive. Crank pins are located on the outside faces of these discs and carry the front ends of the main rods which extend backward to the main crank pins on the driving wheels in the usual manner.

The general construction of the Swedish locomotives is shown in the *Railway Age* issue of April 17, 1937, page 682, (photograph only) and that for the English locomotive in the February, 1936, *Railway Mechanical Engineer,* pages 53 and 60.

The service obtained from these four locomotives has

* Presented at the Convention of the Railway Fuel and Traveling Engineers' Association, held in Chicago, Wednesday, September 29, 1937.

† Chief Mechanical Engineer, Chicago & North Western.

been reported as being quite satisfactory, and we understand that in Sweden at least, it is expected that more of them, of practically the same design, will be built in the near future.

Turbine Locomotives Designed for Service in This Country

About the middle of last year, a 5000-hp. two-unit steam turbo-electric-condensing locomotive was ordered by the Union Pacific from the General Electric Company, as covered in the 1936 report of this committee.

We had hoped that this locomotive would be completed and in service so it could be covered in this year's report. Work on its construction, however, has been considerably delayed, but it has been reported that it will be completed and ready for test and regular service in the near future.

We understand that this locomotive is to be built in two units, each 90 ft. 10 in. over pulling faces of coupler knuckles and to weigh about 530,000 lb., or a total of 1,060,000 lb. for the complete locomotive ready for service. Each unit is to be of the 4-6-6-4 type and to be of 2500 hp. capacity, making a total of 5000 hp. for the locomotive.

Each unit is to have a high-pressure boiler to furnish high temperature steam to a compound steam turbine which will be geared to an electric generator which will in turn furnish electric current to the six motors on the six pairs of driving wheels. The boilers are to be entirely automatic and burn bunker "C" fuel oil.

Air-cooled steam condensers are to be used to condense all the exhaust steam from the main turbine and also from small turbines used to drive the auxiliaries. We understand that each unit will have a starting tractive power of 80,000 lb., making a total of 160,000 lb. for the locomotive.

The two units are to be arranged so they can be operated as one locomotive or as separate units. The maximum operating speed will be 110 miles per hour. A complete description of this locomotive and all its details will probably be given in the technical press as soon as it goes into actual service.

Experience Obtained from Actual Service

The most outstanding favorable feature of the service obtained from the steam turbine-driven locomotive is its steady, smooth and vibrationless operation. This results in reduced damage to the locomotive itself and to the roadbed, and consequently reduces the cost of maintaining not only the locomotive but also the track, bridges and entire roadway. This is because there are no reciprocating parts in the driving gear of the turbine-driven locomotive and, therefore, no dynamic augment generated by counterbalance weights as is produced in the reciprocating engine-driven locomotive.

One very definite unfavorable fact in the details of the operation of steam turbine-driven locomotives has been brought out in the service obtained from them in both Sweden and England. This fact is that during starting and low speed operation, the steam consumption is very high and, therefore, the efficiency of the locomotive is very low, and if there is frequent starting and a considerable percentage of the time consumed in low-speed operation, the high steam consumption during this period more than offsets the benefits derived from the low steam rates obtained when the locomotive is being operated at higher speeds.

One manufacturer of steam turbines for locomotives in Europe has resorted to a modified form of turbine blade in an effort to flatten the steam-rate curve and obtain lower steam rates during both low-speed and high-speed operation, and thus in a measure overcome the unfavorable conditions referred to above. This style blade, however, increases the steam rate for intermediate speeds and in effect, "robs Peter to pay Paul," which is probably not the best method to improve the over-all steam rate and efficiency of the turbine and drive for locomotive service.

The steam turbine-driven and also the reciprocating engine-driven locomotive horsepower curves start at zero and increase to a predetermined point at intermediate speed and then drop off rapidly toward maximum speed and are roughly of parabolic form with the axis vertical.

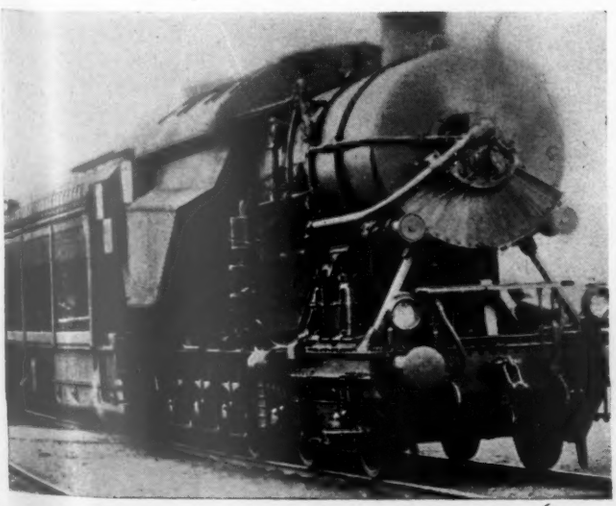
The inherent characteristics of the steam turbine and the relation between the driving wheel diameter and piston speed produce this contour of horsepower curve for the steam turbine-driven and the reciprocating locomotives, respectively. If a three-speed gear were available, similar to what is used in automobile construction, it would be very desirable not only for steam turbine but also for reciprocating steam engine driven locomotives.

This construction would flatten the horsepower curve and make greater horsepowers available at both low and high speeds and provide greater starting tractive power, all of which is very desirable. To date, three-speed gears, or even two-speed gears, have not been considered practical to transmit large horsepowers for these two types of locomotives. Electrical manufacturers have been confronted with similar problems in the construction of electrical equipment for rail service.

It has been necessary for them to provide a compromise or considerably modified construction in an effort to produce equipment to deliver high starting tractive power and a reasonably flat horsepower curve for low intermediate and high-operating speeds. This compromise or modified construction for electric drive equipment, namely, generators, controllers and particularly the motors has resulted in a considerable loss in efficiency and a lowering of the horsepower output curve.

Research Work Done by the Committee

As a means of obtaining greater fuel economy and lighter and better operating power units, this committee has for a number of years, been endeavoring to develop and recommend to this association, a steam turbine-driven condensing locomotive with a transmission



Early Ljungstrom turbine locomotive built in Sweden for service in Germany

of higher efficiency and, therefore, delivering greater horsepower at the drawbar for the weight and cost of the power unit than can be obtained from either the present direct mechanical, or the electrical transmissions.

The electric transmission, as far as operating characteristics are concerned, is very desirable, and is more flexible than the direct-drive transmission.

[The report, which was signed by Chairman L. P. Michael, chief mechanical engineer, Chicago & North Western, included at this point a detailed description of a condensing steam-turbine locomotive with mechanical transmission, the principal features of which may be summarized as follows.—Editor.]

The locomotive is to be moderately streamlined, 84 ft. long over couplers, to weigh 500,000 lb. ready for service, have 64,000 lb. starting tractive power, develop 4,000 hp. on slightly less than nine pounds of steam per hp. per hour and condense all of this steam including that from auxiliary turbines and use it again as boiler feedwater. The boiler is to deliver steam at 1200 lb. pressure and 850 deg. F. temperature to the steam turbine.

The boiler is to be of the uniflow, single-coiled-tube type, with preheater, evaporator, steam separator drum and superheater for steam generation and with a cylindrically shaped burner through which vaporized distillate fuel oil and preheated air is blown and burned on the outside of the burner in a short blue flame similar to that from a gas plate or Bunsen burner.

The gases of combustion are to pass radially outward from the burner through the evaporator coils, superheater and preheater section of the coiler tube and then through a combustion air heater before passing out the stack. An efficiency of 85 per cent is obtained with this type of boiler which is of a very small and compact design and comparatively light weight.

The steam turbine to be of the impulse-reaction type designed for a speed of 8000 r.p.m. at 120 m.p.h. The bladed portion of the turbine to consist of two 24-in. mean-diameter Curtis wheels in series followed by 18 stages of reaction blading.

The steam condenser is to be of the cast-aluminum fin-section or, copper-fin-tube type located and forming the entire roof portion of locomotive cab the full length of the locomotive frame. Eight 9-ft. diameter fans are to be used to draw air through ducts at the ends and sides of the cab and blow it upward through the condenser. The condensation to be drained to a hot well from which a triplex pump is to return it to the boiler.

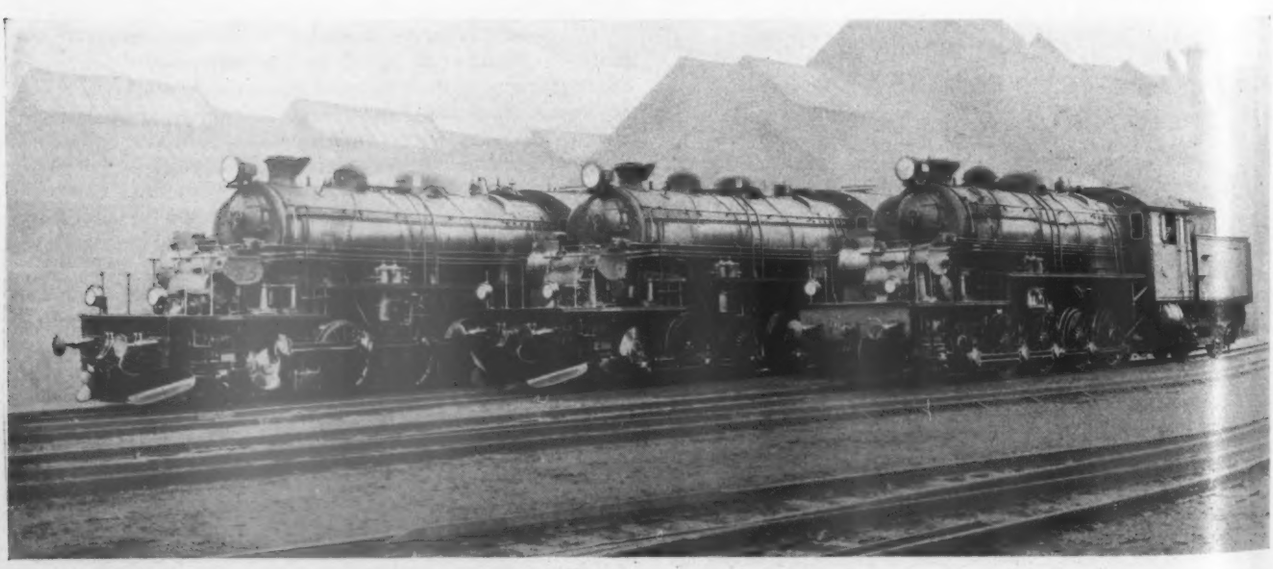
The transmission of power from the steam turbine is to be through a reducing gear from about 6700 r.p.m. to 1800 r.p.m. at 100 m.p.h. to a driving shaft and through a hydraulic coupling, epicyclic traction increasing gear at low speeds (the latter to be inoperative at higher speeds), then through a reversing gear to shaft driving hypoid pinion and gear on each driving axle.

The locomotive is designed to be operated at 110 m.p.h. at equal speed and tractive power in either direction. The efficiency of the direct driving gearing from steam turbine to the rail at the driving wheels is expected to be over 90 per cent, or about 15 per cent higher than for the electric transmission used with Diesel powered or steam-turbine powered locomotives.

The higher efficiency of direct mechanical driving gearing, combined with small sized but efficient boiler, turbine and condenser, permit this locomotive to be built in one unit, whereas, a steam-turbine powered locomotive with electric transmission must be built in two units and a Diesel-powered locomotive in three units to transmit the same power at the draw bar. This would indicate that the turbine-powered locomotive with direct mechanical transmission can be built at less than half the weight and at slightly more than half the cost of the locomotives with electrical transmission.

The cost of maintaining these locomotives is expected to be in direct proportion to the number of units or the weight of each type of locomotive.

One important factor of the operation of these three types of locomotives, was brought out by the writer of this report. This was that the quantity of fuel oil used by each type of locomotive will be such that with the higher efficiency and lighter weight of the steam-turbine-powered locomotive with direct mechanical transmission using furnace distillate fuel at 5 cents per gal. and the steam turbine-powered locomotive with electrical transmission using Bunker "C" fuel at 3½ cents per gal. and the Diesel engine locomotive with electric transmission using Diesel distillate at 5½ cents per gal., the cost per horsepower hour at the draw bar, would be practically the same for the three types of locomotives, even though the Diesel (engine only) had the higher efficiency and the turbo-electric used the cheaper Bunker "C" fuel oil.



Ljungstrom non-condensing turbine locomotives in Sweden—Locomotive No. 71 was placed in service in 1932; Nos. 72 and 73, in 1936

EDITORIALS

A Good Source of Information

Committees appointed by the mechanical associations sometimes have great difficulty in securing information which they need in making their studies and reports. Moreover, frequently a committee will present a report which is far from what it should be, considering the fact that more complete and authentic information than is included in the report is readily available, if one knows where to look for it.

Officers of the various mechanical associations and members of the technical committees should not overlook the fact that the Association of American Railroads has established a Division of Engineering Research, under the direction of L. W. Wallace, who makes his headquarters at the Chicago office of the association. This division has made plans for and is aggressively prosecuting research into a number of important technical problems. Beyond this, however, it is establishing its work on the basis of a service agency, with a technical staff to supply information to any of the groups which may call upon it. Here, then, is an invaluable agency which can be of great assistance to committees which may be appointed during the coming weeks to prepare reports for next year's conventions.

Building a Convention Program

The mechanical associations, most of which resumed their activities this year, suffered heavy losses in membership during the depression and naturally may be expected to have considerable difficulty in rebuilding and toning up their organizations for the most effective functioning. It must be admitted that, considering the fact that they had such a short time in which to prepare their programs, they made unusually good showings at this year's meetings. On the other hand, if they are to meet reasonably well the demands that will be made upon them, they must put a lot of hard work into their future programs, giving more attention to a proper coverage of their respective fields and going more thoroughly into details. This will naturally require a high type of committee service.

It is significant that both the Railway Fuel and Traveling Engineers' Association and the Master Boiler Makers' Association kept their committee organization pretty well intact during the depression years, and were successful in featuring excellent committee reports on this year's programs. The other associations filled in the gap by calling upon experts for addresses on vital problems in which their members were interested, and through the provision of open forum discussions. These devices are excellent, but they cannot, of course, fill the place of carefully prepared committee reports. All of the associations are faced with the problem of appointing well-balanced committees to study and report on the more important problems in their respective fields. This is no simple task and it must be done immediately to insure strong and well rounded-out programs for next year. It would seem well, also, after the committees are appointed, to give them more or less detailed instructions as to what is expected of them and exactly how to proceed. Many of those who will be invited to function on the committees may have had little if any experience in such work, and they cannot be expected to perform efficiently without some guidance.

A good chairman is indispensable, but there has frequently been much misunderstanding as to the qualities of a good chairman. A good chairman is not a man who will do all the work himself. Obviously a report prepared under such conditions will be limited in perspective and findings. A good chairman is one who can get the members of his committee to co-operate in gathering information and in assisting to digest it. While the chairman may have to do a large part of the work in finally whipping the report into shape, he must have real co-operation from all of his associates. Beyond this, however, every member of an association should feel a responsibility for furnishing such information as he can to the various committees.

The task of the executive committee of each of the associations is to see that the committee assignments are made at once; that the committees are followed up from time to time to insure that the work is being carried forward aggressively; that additional committees are appointed to meet any emergencies that may arise during the year; and that the reports are available early enough so that copies may be made and furnished to the members well in advance of the annual convention. Only in this way can the most thorough and constructive discussions be held.

In many instances the members of a committee will be so widely scattered that it may be difficult, if not impossible, to hold meetings, and a large part of the work will have to be done by correspondence. Railroad mechanical department supervisors and foremen, like other busy men, are, generally speaking, poor cor-

respondents, and unless they make an unusual effort, will delay and dally along until the report will finally have to be whipped into shape under almost impossible conditions, and can hardly be expected to reflect great credit upon the organization. This handicap presents a very definite challenge for intelligent and earnest effort and co-operation.

The *Railway Mechanical Engineer* believes in the practical value and great importance of the mechanical associations. If they function successfully it will not only be to the great advantage of the railroads, from a dollars and cents and efficiency viewpoint, but it will very greatly enhance the positions of the men who are responsible for making such records. On the other hand, if the members and officers of the associations are not willing to make a reasonable sacrifice and make a real effort, the railroads and the members will fail to profit and the associations will have to be discontinued because of lack of vitality. Several of them faced up to their possibilities in splendid shape this year. Have they the ability to keep up the pace over the long run, or have they simply qualified as sprinters?

Co-operation Between Mechanical Associations

In reorganizing the mechanical associations and scheduling their meetings over a four-day period, with a common exhibit, certain inconsistencies developed at the recent meeting at Chicago, the elimination of which will require careful consideration on a co-operative basis between the various organizations. It has always been the practice, for instance, for the General Foremen's Association to schedule reports and addresses on both locomotive and car repair shop and maintenance problems. Obviously there was a certain sound basis for this, since many of the general foremen have jurisdiction over both classes of work.

On the other hand, the Car Department Officers' Association, which has restricted its activities to the car department, has also in the past given much attention to car repair shop and maintenance questions, both associations thus duplicating their work in part. The inconsistency of this was clearly apparent at the Chicago meeting, when the two associations met in nearby rooms, on the same floor of the hotel, at the same time. An executive officer of a railroad which had representatives attending both meetings was rather perplexed, and indicated that some of his men were not sure just which meeting they should attend at certain times.

Quite obviously the problem could be solved by restricting the activities of the General Foremen's Association to locomotive shop and enginehouse problems, but staggering the meetings of the General Foremen's and Car Department Officers' Associations so that the general foreman interested in both locomotive and car matters could attend that part of the car officers' meeting in which he was primarily interested; or possibly some way could be found of considering such matters at joint sessions.

Matters relating to management problems, training of workers and public relations are of common interest to members of more than one of the associations, and here again, the question of scheduling joint sessions is worthy of consideration. A study of the programs of the four associations which met in Chicago indicates the presence of several outstanding speakers on such topics, who were listened to by only one of the groups, although a joint session of several of them might have profited greatly from these addresses. The larger audiences would also have afforded greater justification for the time and attention which these officers gave to the preparation of their addresses and attendance at the conventions. These matters might well be given serious and careful consideration by the officers of the different associations in planning next year's programs.

Wheel Shop Practice Needs Checking

Doubtless no car-wheel shop in the country is so well equipped, organized and supervised that no further improvements can be made in the methods employed for turning out car wheels for freight and passenger service. It is equally true that a certain number of shops—perhaps more than is generally realized—on the other end of the scale, are following wheel-shop practices which can be accurately described only by the word used in referring to bad eggs when they are bad enough.

Wheel shops in which unsatisfactory repair practices are followed include those operated, in some instances, by car builders and private car owners as well as railroads, and usually it is the small poorly equipped shop which is the principal offender. In an effort to improve still further the performance of chilled-iron car wheels, the Association of Manufacturers or Chilled Iron Car Wheels has recently sponsored a study of actual wheel shop practice, which indicates that, in many instances, reduced wheel life and possibly even failures, charged to design or manufacture, are really due to malpractice in assembling the wheels and axles in the wheel shop.

A specific study of conditions in six shops taken at random in one important railroad center showed that at all of these shops wheels were bored off center in varying amounts from 3/32 in. to ⅜ in. Wheels were bored as much as ⅛ in. out of true with the flange. One five-jaw boring mill was discovered with the boring bar .015 in. loose in the housing and only four of the five jaws holding the wheel. As the result, wheels were bored ¼ in. off center and with two tapers of .005 in. each, small in the middle of the hub, and .004 in. out-of-round.

Similarly, axles were found turned in worn-out ma-

chines with bent spindles and bad centers, resulting in inaccuracies of as much as .023 in. taper and .004 in. out-of-round in journals and wheel seats. Wheel presses also were inadequate to do a satisfactory job of wheel mounting, in one case there being 10 tons difference in reading between the indicating and the recording gage, and, in another, a machine equipped with a 14-in. ram had a recording gage designed for use with a 9-in. ram machine.

Not all of the difficulty can be charged to inadequate machinery, however, as in some instances the wheel bores are measured with calipers, thus rendering totally ineffective the accurate measurement of axle diameters with micrometers. Press tolerances are sometimes estimated by holding calipers up to a light; wheels are gaged at only one place in mounting; wheel sticks are used on journals in turning wheels. Additional information regarding the results of this inspection of a number of car wheel shops will be shown more in detail in an article in a subsequent issue of *Railway Mechanical Engineer*.

The indictment of current wheel-shop practice, presented by this study, is, of course, not general, for many car-wheel shops, operated by car builders, private-car owners and railroads, are turning out excellent work. The importance of wheel-shop work, as effecting the safety and economy of railway operation, is such, however, that in even the best of shops, a comprehensive check of detail shop practices may well be undertaken to make sure that no pair of wheels, deficient in any particular, is permitted to leave the shop. Obviously car-wheel shops which are less well-equipped and supervised, should in varying degree, be improved to meet the requirements of this exacting phase of equipment maintenance work.

The primary responsibility is upon managements to furnish adequate wheel-shop machinery and equipment and see to it that practices, recommended in the Wheel and Axle Manual of the A.A.R., Mechanical Division, are religiously followed. It is also the duty of wheel-shop superintendents and foremen to impress upon their superior officers, both in season and out of season, the urgent necessity of installing modern equipment and adopting the modern methods without which satisfactory wheel-shop operation is impossible.

New Books

CAR BUILDERS' CYCLOPEDIA OF AMERICAN PRACTICE. *Compiled and edited for the Association of American Railroads, Mechanical Division. Published by the Simmons-Boardman Publishing Corporation, 30 Church street, New York. 1,308 pages, 8½ in. by 12 in. Price: Cloth bound, $5; leather bound, $7.*

The fourteenth edition of the Car Builders' Cyclopedia follows the same general arrangement as previous editions. The material is so arranged and indexed that reference to the general index or the list of contents gives the location of each class of cars or appliances, while the complete detailed index embodied in the definition section gives a reference to each specific car or part. Other indexes—Directory of Products, Trade Name Index, and Alphabetical Index—are given in the last pages of the book. In the fourteenth edition, however, the division into sections has been more clearly defined and the arrangement somewhat changed in order to make the material more readily accessible. The list of contents by sections and sub-divisions and the alphabetical index to car parts have been improved and a summary of the contents of each section has been added on the first page of the several sections. The Cyclopedia gives definitions and typical illustrations of cars, their parts and equipment; descriptions and illustrations of shops and tools employed in their construction and repair, and cars built in America for industrial operations and for foreign railroads. New designs of cars and appliances in the field of railway car construction have been included as far as possible so that this edition might contain the latest practices in American car construction and equipment.

HOW TO MAKE ALIGNMENT CHARTS. *By Merrill G. Van Voorhis, M.Sc. Published by the McGraw-Hill Book Company, Inc., New York. 114 pages, 6 in. by 9 in. Price, $2.50.*

The purpose of this volume is to provide the most direct instructions on how to make nomographic or alignment charts for the solution of engineering and other formulas. Major stress is placed on how to handle the various types of equations. Theory of construction, which is not essential to the understanding of the procedure in making the charts, is not interspersed with the material but is briefly outlined in the Appendix for reference. Graphical construction methods are described wherever practical, along with a mathematical method. Examples are given with every type equation to demonstrate the detailed procedure for making the charts according to the directions provided.

DIESEL PLAN BOOK AND ENGINE CATALOG. *Volume Two. By John W. Anderson. Published by Diesel Engines, Inc., New York. 320 pages, 13½ in. by 11 in. Price $2.00.*

The 1937 edition of this catalogue is an addition and supplement to the 1936 edition. It contains a record of further accumulations of engine and plant designs, of studies of plant installation problems, and of experience gained in Diesel engine application. The catalogue section includes descriptions, diagrams and illustrations of many sizes and types of engines. The plan book section describes different Diesel plants and gives reports of studies of individual application and installations plus discussions on various special problems. This Diesel engine catalog is of particular interest to railroad Diesel maintenance and operating men because of the detail information which it contains on the various types of engines and their accessories.

Gleanings *from the* Editor's Mail

The mails bring many interesting and pertinent comments to the Editor's desk during the course of a month. Here are a few that have strayed in during recent weeks.

Torn Between Two Loves

Played a dirty trick on the railroads by driving a new car home from Flint, Mich., but still am a rail fan, as I did not ride any stages on my round trip in crossing the continent.

More Efficient Car Repair Practices

You have been hitting the ball, but would appreciate a little more for the car department—something in the line of standardizing car repair work and the use of standard and efficient tools. Some railroads use different practices at each car repair point, although uniform practices would save time and money. Care should be taken so that the best methods are adopted.

Walt Wyre a Help and Inspiration

I desire to take this opportunity to express my appreciation of the articles in the *Railway Mechanical Engineer* by Walt Wyre. There is much of interest in his articles, which, if taken advantage of by railroad officials and others, would certainly help to lift the load from many roundhouse foremen and other supervising officials on the railroads, since we all know that the impossible is sometimes expected of such officials.

Mechanical Conventions at Chicago

I really enjoyed meeting a number of mechanical men and looking over the exhibit. I was impressed with the fact that there were a lot of serious minded men present. I do think that if another such group of meetings is held at one time, there could well be some joint meetings, as some of the subjects discussed by one association were very pertinent to the delegates to another meeting held in an adjoining room, and vice versa.—*Executive Officer.*

How Can We Compete With Them?

No one can accuse the Interstate Commerce Commission of being very tender-hearted when it comes to dealing with railway owners and managements. I wonder if you were as amazed as I was at the report of I.C.C. Examiner R. W. Snow, in which he recommended for common and contract carrier motor carriers as maxima a 60-hour week, or not more than 70 hours in any period of eight consecutive days, with limits of 15 hours "on duty" and 12 hours "at work" in any period of 24 consecutive hours. How can the railroads compete with such common carriers? Remember, also, that the motor transport carriers operate over public highways, while the railroads must not only supply their right-of-way, but must pay heavy taxes upon it.

When He Stopped to Think!

When your representative was here last month I told him I did not care to renew my subscription to the *Railway Mechanical Engineer.* In the last few days, however, I have been reviewing back copies and must frankly admit that I did not realize until now the benefits I had obtained from them. I decided I had better send you my check, which is enclosed herewith, as I do not wish to miss any numbers.

Where Will They Find the Space?

First, in discussing the mechanical conventions at the Hotel Sherman in Chicago last week, he stated that it was the most successful and profitable meeting he had ever attended or exhibited at, not excluding the Atlantic City conventions. He lamented the fact that they had taken such small space at the convention and thanked me very much for urging him to be there. He said that next year they will have an exhibit that will probably steal the show.

Checking and Repairing Men

At least one statement made by Vice-President Woodruff in his address before the International Railway General Foremen's Association, and reported on page 435 of your October number, should have been played up in prominent, black face type. "Years ago," said Mr. Woodruff, "many men were fired—thrown on the scrap pile just like broken castings. Now we weld the castings and it is part of the foreman's job to use the same principle with his men. The old practice of hiring and firing is obsolete. * * * A human being needs checking just the same as a locomotive boiler, following up with the necessary repairs." Here is a unique and yet most rational conception of the job of a foreman or supervisor, and yet I wonder how many of us recognize it as a vital, or possibly the most vital element in our work. I know it gave me quite a jolt when I read it.

Waste Grabs and Hot Boxes

The studies to be conducted in the Chicago terminal district under the sponsorship of the Bureau of Explosives and the Freight Claim Division of the Association of American Railroads, on the effect of rough handling of freight cars to reduce damage to equipment and lading, is timely. No allusion has been made to the study of waste grabs from packing in journal boxes, which might well be included in the studies, since the majority of hot boxes are caused by waste grabs formed in terminals. The majority of hot boxes occur from 25 to 50 miles from principal terminals. If the sub-committee to be appointed, including "representatives of other departments to analyze the handling of cars," will include journal box packers, oilers and inspectors familiar with journal box performance, additional data on the effects of rough handling in disturbing journal packing, jumping of bearings off journals at speeds from five miles per hour, upward, will be illuminating, especially to operating supervisors, who are still unconvinced that journal box performance is affected by rough handling. This opportunity offered in the proposed terminal studies will provide an excellent set-up for procuring definite data on potential hot box conditions.

THE READER'S PAGE

More Hot Boxes In the Summer?

To the Editor:

Relative to the lubrication of car journals, the railroads have realized the advantage to be gained by using a satisfactory grade of waste and oil. Not long ago it was the practice to use two grades of oil, commonly referred to as summer and winter oil, but this was found to be impractical and as a result it was quite generally agreed that a suitable grade of oil should be used for all-year service. Unquestionably an oil that will perform satisfactorily under all climatic conditions would be ideal. It is fully realized by the writer that the lubricant alone, no matter how good the quality, will not produce satisfactory results unless accompanied by close inspection to see that the journal-box packing is properly applied and all mechanical parts are in proper order.

The writer is fully cognizant of these requirements and although they are rigidly adhered to on his road it is his experience that more hot boxes occur during the summer, especially when it is extremely hot, than during other periods of the year. While not an alarming situation, it raises the question: Why should there be more hot boxes in the summer than in the winter?

It would be interesting to learn of the experience of others and what have been their findings and remedies.

Traveling Car Inspector.

Drill Tang Breakage

To the Editor:

In your June issue of *Railway Mechanical Engineer* I read with interest an article concerning drill tang breakage. It seems to me that the statements made are true enough, but that they do not go far enough.

Depending upon the size of drill, there is a clearance of at least 0.010 in. between the thickness of the tang of the drill and the width of the keyway in the socket. If the drill shank and the socket are not in 100 per cent contact due to the presence of some foreign matter, or damaged taper, and the holding power at the taper becomes insufficient, there will be a movement between the drill taper and the socket taper of about 0.010 in. until the tang takes hold. The load is suddenly applied to the tang which often twists off. Had this load been applied statically rather than by impact, it would have been of much smaller magnitude with much less destructive results.

I have found a means of remedying this situation which has worked out excellently for me. First, clean the drill and socket tapers. Second, see that the tapers are not damaged. Then, put the drill in the socket, but before "driving the tapers home," twist the drill counterclockwise, or in the opposite direction of its rotation until the corners of the tang are touching the sides of the keyway. Then "drive the tapers home."

In this way there can be no relative movement in the socket, with the resulting impact loading of the tang as both the tang and tapers are holding the drill from the very start. This method is very effective and so simply applied that your drill tang breakage should show a drop as soon as it is instituted.

Leonard A. Kroll.

Thermal Checks in Hubs of Engine-Truck Wheels

To the Editor:

The letter from "General Foreman," in the September issue of the *Railway Mechanical Engineer,* requesting information on thermal checks in the hubs of engine-truck wheels, focuses attention on a locomotive defect about which little mention has been made heretofore. Is this because the condition is not general, but rather is one being experienced by only a few roads? It certainly appears to be a serious problem on the road employing the author of the previously mentioned letter.

Thermal checks usually are the result of high concentration of compressive forces on rapidly rotating surfaces, the generation of heat from friction between the surface being a factor which accentuates the condition. Therefore, it is altogether possible that the thermal checks, as described by "General Foreman" may be the result of combined factors. If the road is one with sharp curves, the lateral pressure between the faces of the engine-truck boxes and the wheel hubs might be excessive and approach the point where checking might start, this being especially true if high speeds are maintained on curves. Again, if many reverse curves are encountered, and high speeds are maintained causing alternate impacts on opposite wheel hubs, the reversal of stresses might be a contributing factor to thermal checking. Undoubtedly the mechanical condition of the engine truck itself, including spring rigging, can also be a contributing factor if not maintained properly.

In discussing any problem involving rubbing surfaces, one should have a knowledge of the metals used. "General Foreman" neglected to state whether the box faces or liners are of steel, brass or another alloy. Assuming that the hub face is steel and the road and operating conditions are as mentioned in the preceding paragraph, that is, sharp curves and high-speed trains, then high lateral forces on single curves, heavy impact forces of reverse curves and excessive friction between the faces of the wheels and the hubs will undoubtedly present the most favorable conditions for promoting thermal checks on the wheel hubs. Are these the conditions which actually exist on "General Foreman's" road? It seems probable because thermal checking of engine-truck wheel hubs occurs very rarely when precautions are taken to hold friction between the box face and the wheel hub to a minimum by employing an alloy box liner or box face.

There are many types of alloys and designs of liners, both floating and anchored, from which "General Foreman" might select one that would serve as aid in solving his problem. Perhaps the writer is presumptuous in assuming that such remedies have not been tried. It would be interesting to learn what steps "General Foreman" has taken to solve his problem.

Master Mechanic.

IN THE BACK SHOP AND ENGINEHOUSE

Device for Forming S-Hooks

The fabrication of S-hooks of ¼-in., ⅜-in. or ½-in. stock for supporting cab curtains, air hose, signal hose and steam-heat hose can be accomplished with remarkable ease by using the device illustrated in this article. The device, as shown in Figs. 1 and 2, consists of linkages *A*, *B*, *E*, *F*, *G* and *H* and a handle *J* fitted with two conduit nipples around which the hook is bent. Fig. 1 illustrates the device with a straight section of round stock in position ready for bending; a completed S-hook is shown removed from around the nipples and set on the edge of the device for illustrating its shape.

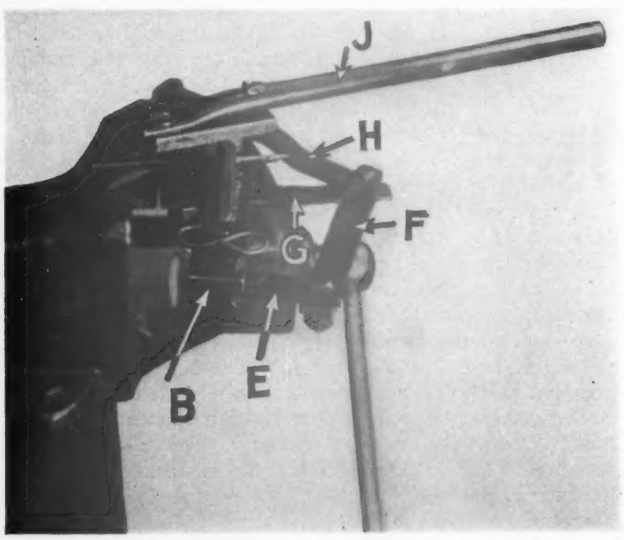


Fig. 1—The S-hook forming device with round stock in position for bending. A completed hook removed from the nipples is illustrated

The parts of the device are lettered similarly in Figs. 1, 2 and 3. Fig. 2 shows the starting, halfway and end position of the handle *J* and the various links during the forming of a hook, while Fig. 3 shows the details of the major parts. The accompanying table lists the various parts necessary to make the device.

List of Materials for the S-Hook Bending Device

Part	No. required	Description*
A	1	⅜ in. by 2 in. by 9 in. flat iron
B	1	⅜ in. by 2 in. by 9½ in. flat iron
C	1	½ in. by 2 in. by [illegible] in. flat iron
D	1	⅜ in. by 1¼ in. by [illegible] in. flat iron
E	1	⅜ in. by 1¼ in. by 5¼ in. flat iron
F	1	⅜ in. by 1¼ in. by 10½ in. flat iron
G	1	⅜ in. by 1¼ in. by 9¾ in. flat iron
H	1	⅜ in. by 1¼ in. by 12 in. flat iron offset near the middle to line up with other parts
I	1	⅜ in. by 2 in. by 5 in. flat iron
J	1	¾ in. diameter by 23 in. long conduit
	1	¾ in. by 2 in. pipe nipple, standard thread on one end only
	1	¾ in. by 2¾ in. pipe nipple, standard thread on one end only
	1	¾ in. by 2½ in. stud threaded ⅝ in. from one end only
	1	¾ in. by 4 in. stud threaded 1¾ in. from one end only
	6	½ in. by 2 in. bolts
	6	½ in. nuts
	1	¾ in. nut

* All parts to be drilled or drilled and tapped as shown in Fig. 3.

Parts *C* and *D* are notched as shown in Fig. 3. The long edge of part *C* is welded to the top of part *A*, and the long edge of part *D* is welded to the top of part *B*, each being set back about ¾-in. from the center of the ¾-in. studs in parts *A* and *B*. One of the ¾-in. studs, which is 4 in. long, is screwed into part *A* while the other ¾-in. stud, 2½-in. long, is screwed into part *B*, both in the location shown in Fig. 3. However, the ¾-in. by 4-in. stud screwed into *A* extends through both *A* and *G* where it is locked in place with a ¾-in. nut. The handle is made up of the two parts *I* and *J*, and two ¾-in. conduit nipples, the longer of which is located as shown in Fig. 3; parts *I* and *J* are fastened together with ½-in. bolts. The remaining ½-in. bolts listed in the table are used to fasten the links *A*, *B*, *E*, *F*, *G*, and *H*, as shown in Fig. 2, at the points where they join. Parts *A*, *G*, and *G* remain stationary during the fabrication of the hooks, while all the other parts are free to move.

In applying the handle *J*, the two nipples slip over the studs in parts *A* and *B*. When the handle is in position there are spaces between the nipples and the lower, middle and top notches in parts *C* and *D* of ¼ in., ⅜ in. and ½-in., respectively. These spaces permit the insertion of ¼-in., ⅜-in. or ½ in. stock in the respective notches, depending on the size of the S hook desired. The round stock to be used for the hook should be cut in lengths of approximately 8½ in.; the proper position of the stock before starting the bend can be ascertained

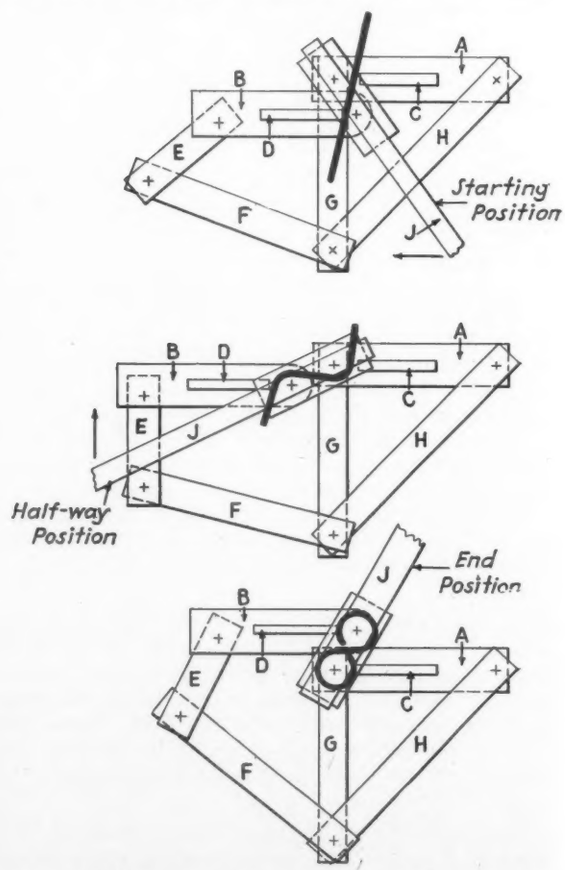


Fig. 2—Various positions of the handle and links during the forming of an S-hook

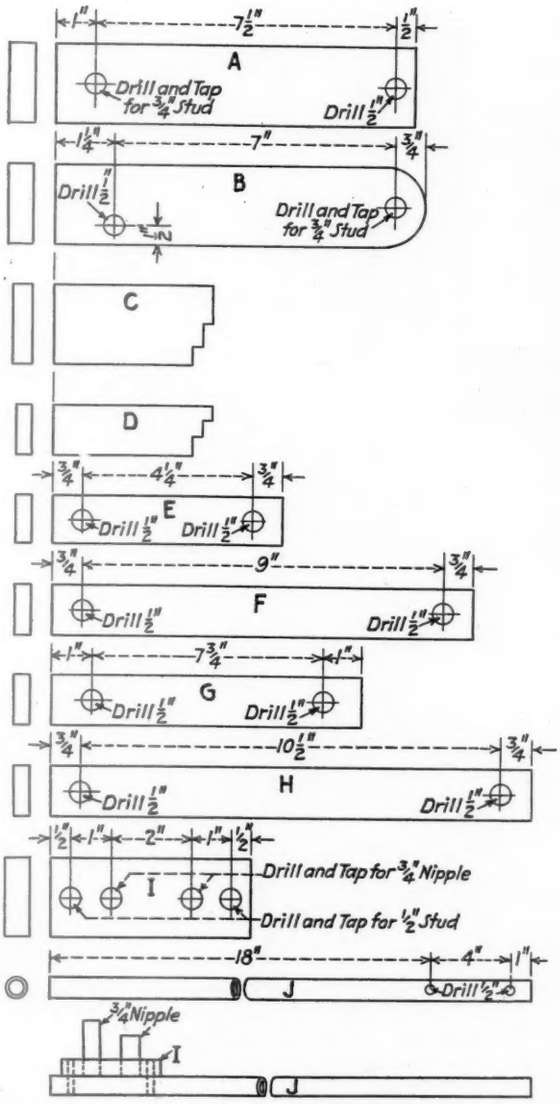


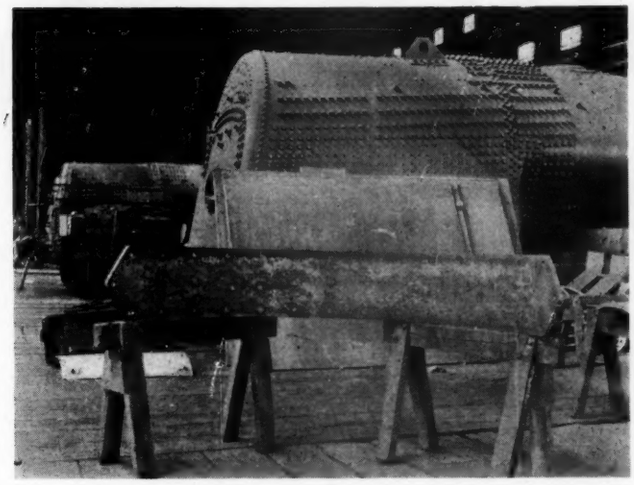
Fig. 3—Details of device for bending S-hooks—See table for a description of the parts

by trial. After the stock is in position, the handle *J* is rotated in a clockwise direction as shown in Fig. 2. The stock, held securely by parts *C* and *D*, is forced to follow around the nipples as the handle *J* is rotated, thus forming the hook. The device is capable of turning out several hooks per minute, regardless of the size stock being used.

Waist Sheet Liner Application

When a crack occurs in a boiler course at the waist and guide-yoke sheet, because of the heavy load carried by this sheet, supplemented by severe vibration stresses, it is standard practice on the Northern Pacific, among other roads, to apply a waist sheet liner between the boiler and the waist sheet angle, as shown in the illustration. The liner, made of ¾-in. steel, is sheared to the correct shape, rolled and fitted hot to the boiler shell. Rivet holes are punched, as shown in the drawing, and the appearance of the liner just before application to the boiler is indicated in the other illustration.

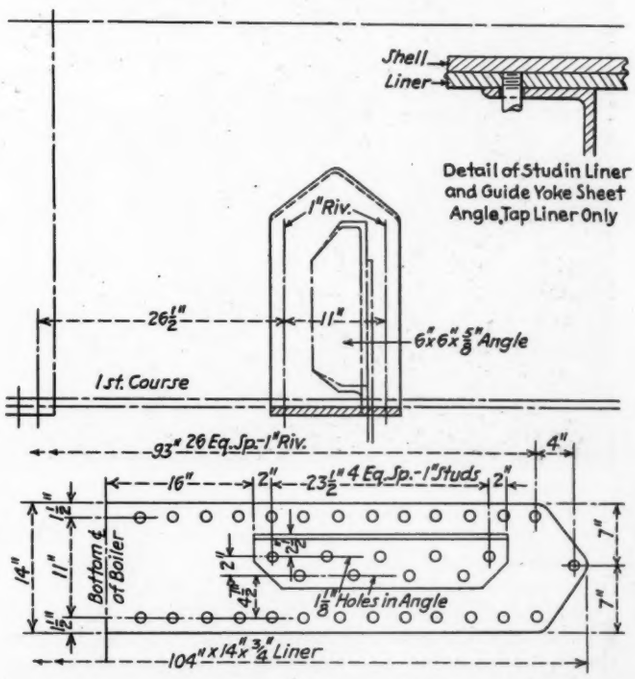
The liner is riveted to the boiler shell in the proper location and caulked to make all joints steam tight. The waist-sheet angle, one on each side, is applied using nine



Waist-sheet liner fitted to the boiler and ready for application

1-in. studs which extend through the liner but not into the boiler shell, as shown in the cross-section detail.

The application of this waist-sheet liner greatly strengthens the boiler construction at a point of severe



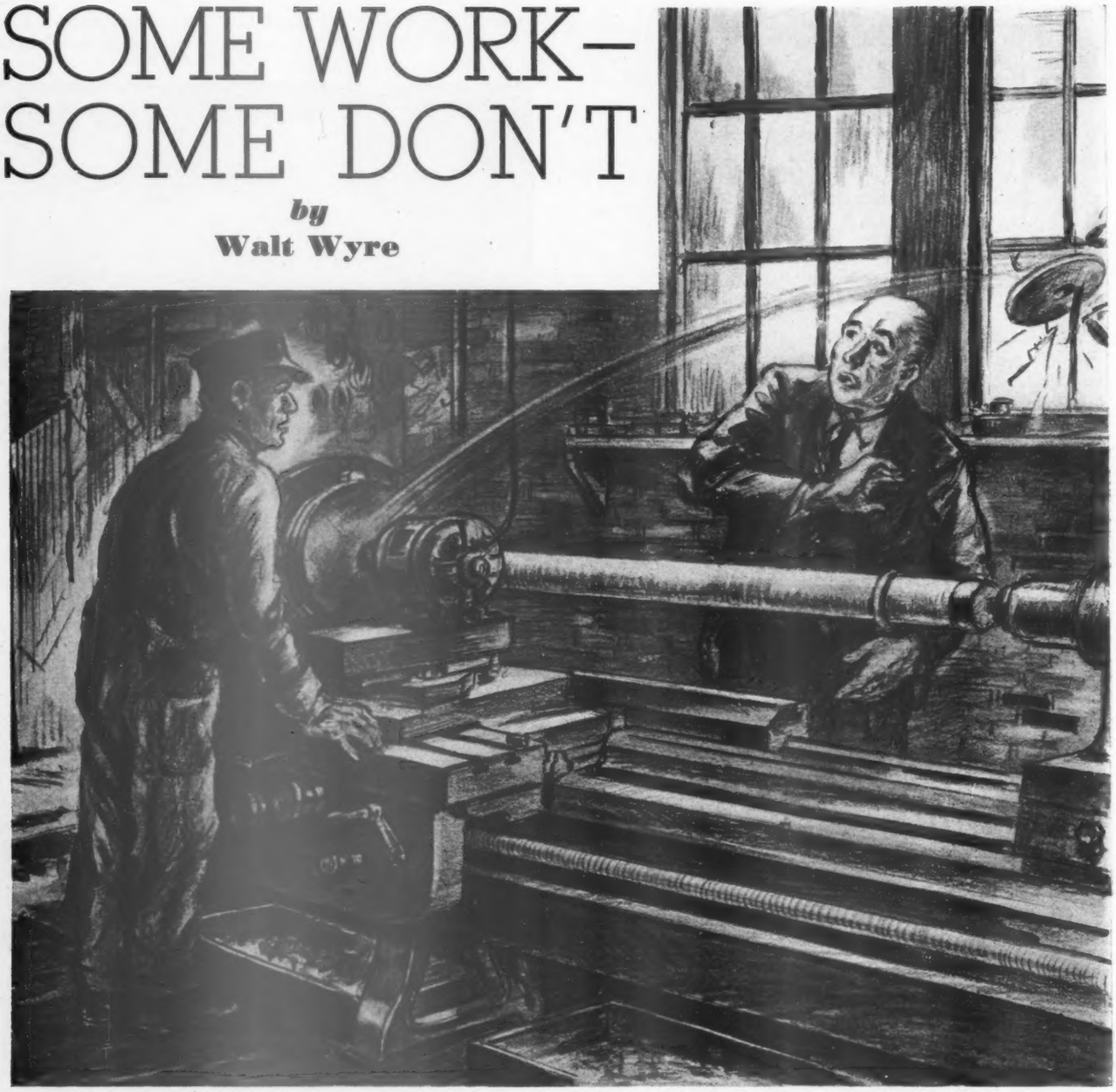
Details of waist-sheet and guide-yoke-sheet liner application

stress and, in the unlikely event that the liner should become cracked, it could be readily replaced and repairs effected without disturbing the main boiler course.

Brittle Rails.—Glass rails were proposed for railway service by Friedrich Siemens of Dresden, Germany, back in 1886. He reported that he had succeeded in casting glass in the form of rails which would be no more expensive than iron and would have the advantage of being transparent; hence any flaws could be detected before laying the track. Tests were actually made in the glass factory to see if the glass rails would be suitable for railroad service.

SOME WORK—SOME DON'T

by
Walt Wyre



Wham! The wheel zipped past Starkey's head and crashed through a window

If the superintendent of motive power had not bragged about the machine for grinding valve gear links and blocks there would not have been so much scrap loaded from the S. P. & W. roundhouse at Plainville, and the company would have saved considerable money. Nobody knows how much the machine cost, there are no records to show, and it's well enough there aren't for the peace of mind of all concerned.

John L. Starkey, general roundhouse foreman, is the daddy of the link grinder and is proud of it and well he might be. It's a good machine and does a nice job. The grinding wheel operates on an adjustable arm that can be set to the exact radius of links and blocks so that when finished they fit perfectly together.

A reverse screw on the principle of a lathe feed reverses the travel automatically at the end of each cut and once set, the machine operates automatically. Takes a little time to set the machine but not a great deal more than required to set up some of the factory-built ones and this one was built right in the shop at Plainville. Starkey not only will, but does, tell any and all that will listen about the link grinder and demonstrate how it works. "Didn't cost hardly anything," Starkey explains. "Just built in spare time."

Jim Evans, the roundhouse foreman, could add that overtime on engines mounted considerably higher during the two months the grinder was being built, but he doesn't. That's not where most of the money spent nor the scrap iron shipped came from. If, when the grinder was finished, it had stopped there, all would have been well, but inventive genius, once inspired, dies hard. When the S.M.P. told Starkey what a good job he had

done, the general foreman set out to modernize the shop at Plainville with home-made tools. Being something of an admitted specialist in grinding, he continued his efforts along that line.

Machinist Cox was calipering the right main pin on the 5070 to make a bushing when Jim Evans came up.

"How is it?" the foreman asked.

"About as round as an egg," the machinist replied. "No wonder the bushings have to be renewed every trip."

Evans bit off a piece of "horseshoe." "Yeah, going to have to hold her and renew the main pins pretty soon. Would do it now if I had another engine. Wish we had a pin grinder—sure save a lot of time and money," the foreman added.

"That's right, and I've been figuring on one," Starkey came up and joined in.

"Think there's any chance of getting a new pin grinder?" Evans asked doubtfully.

"Not buying one—build it," the general foreman replied. "One shouldn't be any harder than that link grinder I built; not as hard, in fact," Starkey added.

"Well, we sure need it," Evans commented.

"Well, I'm going to build one—good one, too." The general foreman headed for the machine shop, his eyes aglow with inventive inspiration.

"Say, Mr. Evans, I've got to get a stud burned out of the 5081 right away. She's called for 4:30." Machinist Jenkins seemed a little peeved.

"Well, why don't you get a torch and burn it out?" the foreman told him.

"That's just the trouble! Boilermakers are using one torch and Martin is using the other cutting out a frame for some kind of machine. Starkey is with him and told me to get the other torch," the nut-splitter explained.

Evans shifted his cud of "horseshoe" from one jaw to the other. "I'll see what can be done about it."

Barton, a boilermaker, was using the cutting torch in the fire-box of the 5072 fitting a patch on a siphon to be welded. That job was just as important as burning the stud out.

"How long will you be using the torch?" Evans asked Martin who was making molten metal fly from a piece of heavy angle iron.

"Oh, I don't know," the machinist said hesitatingly.

"Ain't there but one torch?" Starkey cut in.

Evans hesitated a moment then turned and went back to the roundhouse. "Work noon hour on the 5081. Maybe you can get a cutting torch then." And the first extra hour of labor chargeable indirectly to the S.M.P.'s bragging about the link pin grinder was added to the payroll.

STARKEY has the pin grinder pictured in his mind but the machinist wasn't a mind reader and the general foreman couldn't explain clearly enough for the nut-splitter to understand exactly how the machine was to be built. The mental picture Starkey carried was of the finished machine with no detail of individual parts and made clear understanding of construction difficult. The work progressed slowly with a great deal of cut, try, and make fit.

Starkey spent most of his time with machinist Martin working on the pin grinder, leaving Evans to look after work in the roundhouse alone. Evans didn't mind that so much, but losing his best machine hand for the time was a considerable handicap. On top of that, a big portion of the time Martin was using the best lathe in the machine shop while work needed for locomotive repairs was being held up.

"How's the pin grinder coming along?" Evans asked Starkey one day.

"Pretty good. I'm afraid, though, we're going to have to build a new frame for it. The angle iron we used seems a little light. Seems too springy."

"Think it's going to work all right when it's finished?"

"Oh, sure," Starkey replied. "Come out here and I'll explain how it's going to work."

"Might explain to the master mechanic why overtime is running so high while you're explaining," Evans said, trying to appear to be joking.

At last the pin grinder was finished all except a motor to run it. There was no motor available.

Starkey scratched his head trying to figure out where he could get a motor.

"What size and speed motor do you need?" Ned Sparks, the electrician, asked.

"Well, about a five-horse-power, I'd say, and it ought to run about 1,500 revolutions a minute," Starkey told him.

"It'll either have to be 1,800 or 1,200 r.p.m.," Sparks said, "and I don't know where you can get either one, unless you use the motor on the old drill press. It's not used much," the electrician added.

"We can do that to test the grinder with, and if we need the drill press we can put the motor back on it," the general foreman agreed.

Starkey picked a day when the master mechanic was out of town to try the grinder. Rods were taken off the left side of the 5088 and the machine trundled up to the left main driver.

Every man in the roundhouse not engaged in work of pressing importance was in a place to see without being seen. Locomotive cabs on either side served as grandstands for the occasion. Whispered remarks, witty and otherwise, were rife.

"Looks like a cross between a model-T strip-down and a baby cement mixer," one man commented.

"Wonder where the cobs come out?" another asked.

"When does the threshing start?" a boilermaker inquired elbowing through the crowded cab.

"Right now, if you don't stay off my feet," a machinist informed him.

Starkey, unaware of his knot hole audience, with machinist Martin helping, adjusted the grinder in position.

At last the machine was ready to go. Starkey closed the switch. The motor started. The emery wheel began to revolve while the spindle went round and round the pin like a comet with its fiery trail of sparks.

"That ought to get the job done," Starkey exulted.

"Little rough, isn't it?" Evans stooped to inspect the part of the pin that had been ground.

"Stop it a minute; let's take a look," Starkey said.

"Yes—it is a little rough," the general foreman admitted reluctantly. "Looks like the wheel is bouncing."

"It won't run like that." Evans reached for his plug of horseshoe and started down through the roundhouse.

The pin was rough and "little" didn't describe the condition. Corrugated suited the appearance of the ground surface better than rough. It was as wavy as a woman's head still wet with hair setting solution.

"Maybe a light finishing cut will smooth it up," Starkey said hopefully.

Finishing cuts—not one, but two—helped some, but not enough. And when calipered, the pin showed a decided taper caused by wear of the grinding wheel and spring of the arbor. An attempt to compensate by adjusting the cut as the wheel progressed resulted in rings around the pin.

"He'll get the pin ground if he don't run out of metal

before it's finished," a passing machinist observed, speaking carefully low so the foreman wouldn't hear.

All day Martin worked with the machine personally supervised by the general foreman. Just before five o'clock, the grinder was disconnected and wheeled into the machine shop. Starkey had tired lines on each side of his mouth but he wasn't ready to admit defeat.

Next day a machinist and helper put in eight hours with files and emery cloth smoothing the main pin enough to run without burning up.

Several changes were made in the pin grinder. Some helped, others didn't, but he never got it perfected to the point that it could be called good. The master mechanic finally put a stop to further experimentation on it. The motor was placed back on the drill press. Other working parts were scrapped and the frame was converted into a stand for air pumps.

THE inventive spirit within Starkey received a considerable jolt, but it was only dormant, not dead, and finally revived entirely. Remembering that he had built a link grinder that worked, Starkey was still a specialist in the grinder line.

A tool post grinder was to be his next masterpiece.

Machinist Martin, erstwhile and ex-builder of personally supervised pin grinders was polishing a piston rod in a lathe. Emery cloth was the polishing medium held against the piston rod with a strip of leather belt fastened to the tool post of the lathe. The emery cloth did a nice job of polishing and left the surface of the rod slick as a spanked baby's place where they spank them, but required more time than Starkey thought it should. Hence the tool post grinder.

Finding a motor was the first consideration and, as it happened, easily solved. There was a one-horse 3,600 r.p.m. motor in the electric shop that had formerly been used on a blower fan.

"Just the thing," Starkey told the electrician. "Fix up an extension cord to plug in a welder outlet."

Building a bracket to mount the motor on the tool post and making a mandrel for an emery wheel on the motor shaft wasn't much of a job. Next day the tool post grinder was ready for a trial.

A piston with rod was mounted in the lathe and the home-made grinder secured to the tool post. The general foreman noticed it first. "We'll have to get a bigger wheel," he said.

"Why?" Martin asked.

"The frame of the motor is so large it won't let the six-inch wheel touch the rod," Starkey replied.

"That's right," the nut-splitter agreed. "Want me to get a 12-inch wheel?"

The 12-inch wheel fairly hummed when the motor was turned on. Martin ran the tool post in. The abrasive bit; sparks flew; then, wham! The wheel zipped past Starkey's head and crashed through a window.

"What happened?" Starkey asked anxiously.

"The motor—it's running in the wrong direction," Martin said. "Looks like one of us would have noticed it."

That was soon corrected and the grinding wheel retrieved. The general foreman, still slightly nervous from his recent narrow escape, started the lathe and gently eased the tool post forward and the grinding started. Somehow results were not as expected. Although not as rough as the work of the pin grinder, the finish on the piston rod was far from smooth. In fact, the serrated surface of the rod was rougher than the lathe tool had left it.

Starkey scratched his head. Different grades of grinding wheels helped little or none. The general foreman was about ready to quit when centrifugal force took matters out of his hands. Once more luck was with them. No one was hit by the flying fragments that whistled through the air like pieces from a bursting shell, but that finished the tool post grinder. More time was charged to the link grinder and more material went to the scrap bin.

THE lesson of the tool post grinder was not severe and didn't last long, but it convinced Starkey that he was not an expert on grinding.

The next and most pretentious machine effected the cure; the master mechanic said it did.

Starting with an out of date and little used crank planer, the general foreman decided to build a milling machine. It wasn't to be just a dinky little affair for cutting key-ways and such, but a real honest-to-goodness machine that would finish a cross-head gib with one cut like he had seen pictured in advertisements.

When the general foreman had finished rebuilding the crank planer into a milling machine, the original builder wouldn't have recognized it. The bed operated with rack and pinion instead of from a crank. Milling cutters replaced tool posts. The cutters were driven from an electric motor through an intricate gear arrangement. Twice the weight of the finished machine went into the scrap bin during the three months in which the shop was working on this machine.

Like the previous instances, overtime in the roundhouse increased, knocking the M. of E. allowance as full of holes as Swiss cheese. The master mechanic came in unexpectedly at the time the new milling machine was to be tested. Theoretically, the idea of the machine was good, but lack of proper facilities for building, incorrect calculations at seemingly unimportant points and use of parts that should do instead of ones built to exact specifications sent the idea on a detour.

The table ran too fast, cutters too slow, gears clashed and rattled. The master mechanic came in just as a cutter gouged and jerked the cross-head gib from the bed of the machine and hurled it to the floor.

"What in the devil have you got here?" the master mechanic asked.

"Why—er—it's a milling machine," Starkey stammered.

"Who built it—Rube Goldberg?"

"We built it, in spare time—" Starkey flushed brick red. "It needs a little adjusting and it ought to work all right."

"Well, the next spare time you have, try adjusting it to a place in the scrap bin where the superintendent of motive power won't see it."

"But—" Starkey didn't get a chance to finish.

"I know what you're going to say—we need a milling machine and with a little more time you can make this work. Maybe so, more likely not. There are some tools that can be profitably built in a roundhouse but not many. Machine tool designing is highly complicated."

"The link grinder—"

"Yes," the master mechanic interrupted again. "The link grinder does a very good job and is mighty good, for a home-built machine. It's needed, too, just like we need a lot of other tools, but in the long run most home-built machines cost more than ones bought outright and stand in the way of approval for new ones.

"Maybe some of these days the company will buy some of the tools we need. In the meantime, if the management can put up with the ones we've got, we'll have to too."

After Starkey cooled off he saw that the master mechanic was right.

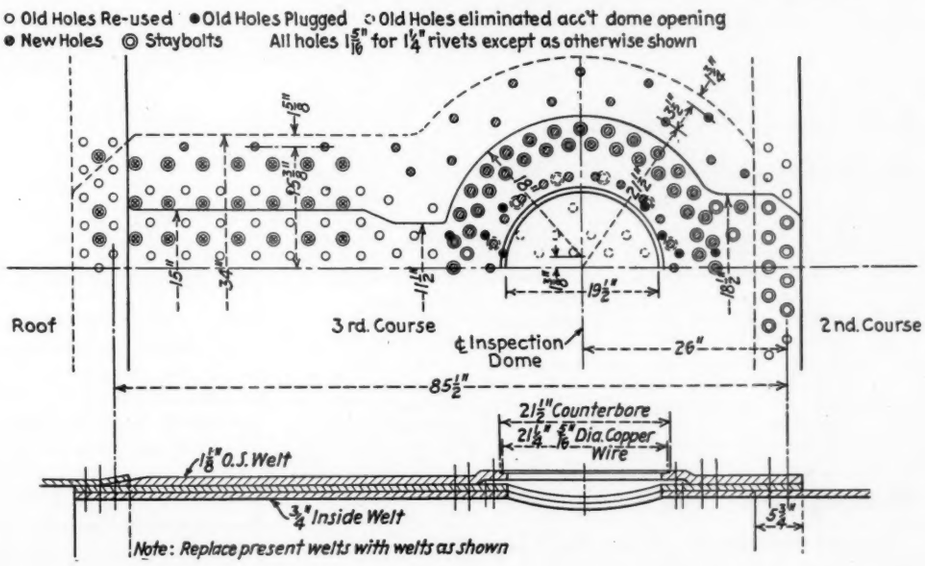
Inspection Man-Hole Liner Applied

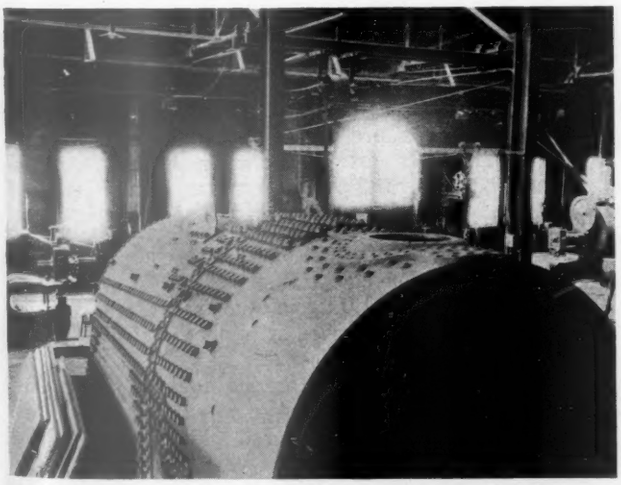
To give access to locomotive boilers for annual inspection purposes without going down through the main steam dome which requires removing the throttle standpipe, it is common practice on some roads to apply a man-hole liner to the longitudinal seam of the third course as shown in the illustrations accompanying this article. Two views showing this liner both before and after application to the boiler are presented in the halftone views and details of the construction and application, as used at the Brainerd, Minn., shops of the Northern Pacific are given in the drawing.

The liner is made of 1⅜-in. boiler steel, formed hot in male and female dies of appropriate design under a 3500-lb. steam drop hammer. The liner is trimmed to size with an oxy-acetylene cutting torch, the seat faced and counter bored for a steam-tight joint with the cover

Inspection man-hole liner flanged and ready for application

Details of application of boiler inspection man-hole liner


○ Old Holes Re-used ● Old Holes Plugged ◌ Old Holes eliminated acc't dome opening
● New Holes ◎ Staybolts All holes 15/16" for 1¼" rivets except as otherwise shown
Roof
3rd. Course
℄ Inspection Dome
2nd. Course
26"
85½"
21½" Counterbore
21¼" 5/16" Dia. Copper Wire
1⅛" O.S. Welt
¾" Inside Welt
Note: Replace present welts with welts as shown



Back end of boiler showing inspection man-hole liner applied

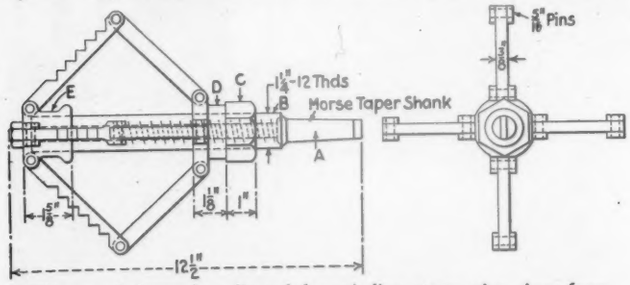
and necessary rivet and stud holes, either punched or drilled as required.

On the boiler, the inside and outside butt straps are removed and replaced by this new liner which incorporates the man-hole. Rivets are applied and seams caulked in the usual manner. Studs are applied around the man-hole opening and a pressed dome cap, made of 1⅜-in. steel, faced, drilled and bolted in place over the liner studs, the joint being made steam-tight by a 5/16-in. copper wire gasket, in accordance with the usual practice.

Adjustable Mandrel For Steam Pipe Rings

The adjustable mandrel shown in the illustration was designed by a western road for grinding steam pipe and superheater header rings from 4 in. to 9 in. in diameter. It is adjustable by means of the nut *C* on the 1¼ in. pipe or tube *B* which threaded for about two-thirds of its length. The Morse taper shank *A* has a spindle portion ½ in. in diameter which extends through the tube *B* and terminates in a threaded portion on which a ½ in. nut is screwed. This spindle portion is centered at the threaded end by passing through a hole in fixed spider *E* which is screwed on the end of the tubing. When this nut is tightened the ball shoulder at the large end of the Morse taper shank centers the spindle in the tubing at the shank end, thus securely holding the as-

sembly which then revolves as a unit. The adjustable spider *D* slips freely over the threaded tubing and by tightening nut *C* the steam pipe ring is securely gripped by the adjustable notched members. The adjusting nut



This mandrel can be adjusted for grinding steam pipe rings from 4 in. to 9 in. in diameter

and spiders may be made of brass and the rest of iron or steel. This mandrel which weighs 10 lb. is an improvement over the customary tapered wooden blocks used to grind in steam-pipe joints.

Locomotive Boiler Questions and Answers

By George M. Davies

(This department is for the help of those who desire assistance on locomotive boiler problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless special permission is given to do so. Our readers in the boiler shop are invited to submit their problems for solution.)

Working Nickel Steel

Q.—Our railroad recently purchased some locomotives which use nickel steel in the boiler construction. I have read numerous articles but have not come across anything that gave me any information as to the proper method of working this particular steel.

I would like some information in regard to heating this metal, as in applying a patch, etc. The general opinion seems to be, to keep heat away from this metal as when fitting up a patch and getting it ready for riveting. R. M.

A.—There is no objection to heating nickel steel, provided it is done properly. It is advisable in heating nickel steel, preparatory to working, that the temperature range from 500 degrees to 700 degrees F. be avoided. Uniform application of heat until the plate is cherry red should produce satisfactory results in forming the patch. When cooler or in the 500-degree to 700-degree F. range, the steel is "blue brittle" and difficulty through damaged plates may be encountered if it is worked in this range.

When local heating is necessary, it should be done over the largest area possible and the use of drift pins should be reduced to a minimum. In all laying up, a large area flatter should be used so that no markings whatever are made in the sheet, or, to be more exact, the sheet surface should not be fiber stressed or cut in sections by the marking of a hammer. In rolling high tensile alloy steel, more time is required, due to the toughness of the metal and the application of pressure on the rolls should be placed on minimum sections at more frequent intervals. Where nickel steels are used, the service demands are exacting and are such that exceptional strength and ductility are required. For this reason, patching is to be regarded as a doubtful practice unless it is done by competent men under proper supervision.

The bulletin on "Nickel Alloy Steels in Railroad Locomotives" discusses the effect of heating and cold working on nickel steel. This bulletin can be obtained from the International Nickel Company, Inc., New York.

Locomotive Fuel Rates

Q.—For what rate of firing are modern boilers designed?—K. F. G.

A.—For all practical calculations the fuel rate of a saturated-steam locomotive can be taken as 4 lb. of coal for i. hp. hr., and for superheated steam locomotive it can be taken as 3.25 i. hp. hr. When developing maximum tractive force, the indicated horsepower for a saturated steam locomotive can be computed as

$$hp._{sat.} = 0.0212\ PA$$

while for superheated steam locomotives the horsepower can be computed as

$$hp._{sup.} = 0.0229\ PA$$

where, in the two foregoing equations, P is the boiler pressure in lb. per sq. in., and A is the cross-sectional area of one cylinder in sq. in. As an example, take a Pacific-type 4-6-2 locomotive with a boiler pressure of 200 lb. per sq. in., 23-in. by 28-in. cylinders and equipped with superheater units. When developing its maximum tractive force this engine, based on the foregoing equation for superheated steam locomotives, will develop ($0.0229 \times 200 \times 415.5$) 1,904 i. hp. hr. Based on the fuel rate of 3.25 lb. of coal per i. hp. hr., this engine will burn ($1{,}904 \times 3.25$) 6,188 lb. of coal per hr.

It should be understood that with higher boiler pressures and steam temperatures as well as improvements in the design of locomotive and appurtenances, the fuel rates will be lower than those previously given, running in some instances to as low as 2.25 lb. per i. hp. hr.

Factor of Safety For Locomotive Boilers

Q.—Would you kindly explain how to arrive at the factor of safety? For locomotive boilers, it is four. What I want to know is how is that figure obtained?—N. K.

A.—The term, factor of safety, is defined as the ratio of the ultimate strength of the material or structure to the allowable stress. In boiler work, the term factor of safety, can be taken as the ratio of the bursting pressure to the working pressure, thus:

$$\text{Factor of safety} = \frac{\text{Bursting pressure}}{\text{Working pressure}}$$

All locomotive boilers operating in the United States must have a factor of safety of four to comply with the locomotive inspection law. This law states:

Rule 2—The lowest factor of safety for locomotive boilers, which were in service or under construction prior to January 1, 1912, shall be 3.25.

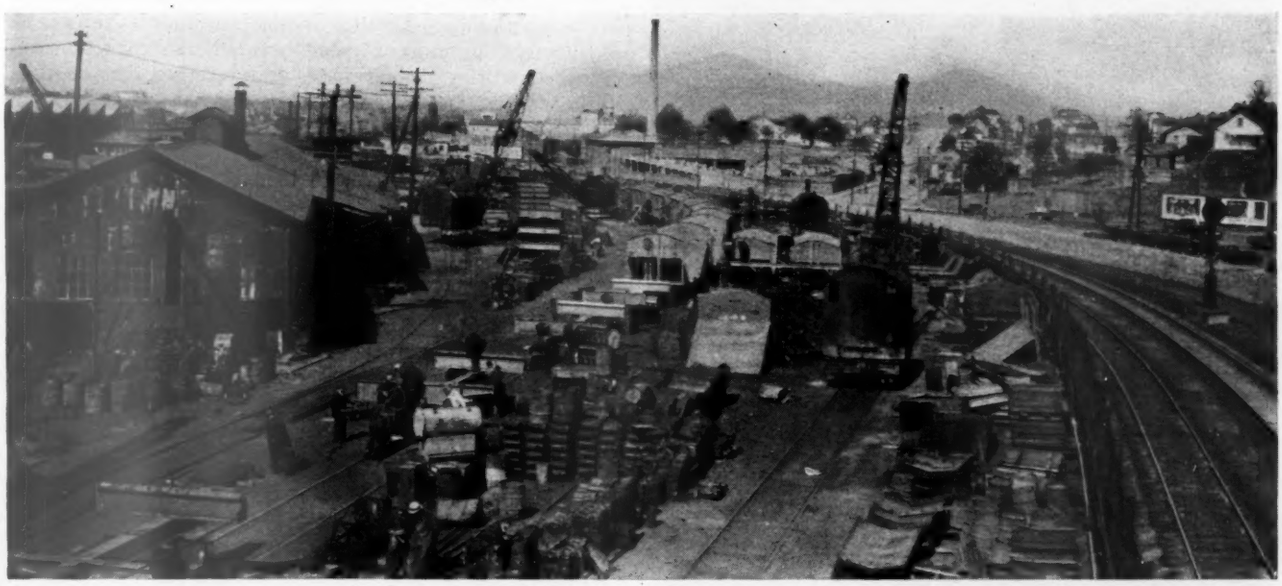
Effective October 1, 1919, the lowest factor shall be 3.5.

Effective January 1, 1921, the lowest factor shall be 3.75.

Effective January 1, 1923, the lowest factor shall be 4.

The factor of safety of four is an arbitrary margin of safety set by law to protect against: (1) Deterioration due to corrosion, (2) Errors in workmanship, (3) The interdependence of parts, (4) The probability of overload, (5) Stresses due to method of suspension, (6) Lack of homogenity in the material.

With the Car Foremen and Inspectors



A general view of the repair yard layout. Fabricating plant at the left; material storage in the foreground and at the right, and the assembly line at the center of the picture

Modern Methods in Freight Car Work*

By J. E. Echols†

These remarks cover the construction of and the rebuilding or heavy repairs to open-top steel cars but would also apply to other classes of cars.

Building New Cars

On the Norfolk & Western, after the type of car has been selected to suit the needs of service, the leading car supervisors are called in by the mechanical engineers and the plans discussed. Drawings are then started in the drawing room and the car supervisors are consulted almost daily while the plans are being prepared. This method has been found beneficial and gives the engineers a chance to make use of the practical knowledge of the car supervisors by taking advantage of the economical way in preparing the details.

In building new cars and in making classified repairs to cars, the progressive system is used. This system is not new. It has been used by many of the contract car builders throughout the country for years, but the real test comes when an old repair shop layout is converted into a progressive system for new car building and results in a successful, economical output without large expenditures for additional facilities.

The Roanoke, Va., car shop of the Norfolk & Western has the minimum in facilities that can be used in securing an output of 10 to 12 new open-top steel cars per working day. It consists of one large capacity multiple punch; one large capacity shear and one large capacity brake with several small machines for single punching, small shearing and bending, and numerous shop-made machines and tools located within and around a shed. The facilities are otherwise outside and in the open.

The shop yard tracks were not originally laid out for progressive new car building, however, it has been accomplished with no change in the layout of the tracks.

The tracks are not equipped with overhead cranes, therefore, five locomotive cranes are used for the operations, with two small tractors and trailers handling the small materials.

The progressive system begins with the unloading of the material and winds up with the light weighing of the cars.

Unfinished material is unloaded along the track leading to the fabricating machines and much time and trouble is saved by storing the different items so that they can be picked out and moved to the machines without unnecessary handling. The heavy material moves west on the north side of the shed. The assembly begins at the west end and moves east on the south side of the shed.

The different operations are grouped in continuous succession from beginning to end, each class of operation being performed at designated places on the construction line, known as stations. These stations are arranged in sequence from Nos. 1 to 11, where the workmen are regularly stationed. The cars, as they progress, are moved to the workmen instead of the workmen going to the cars. The men that have the light operations are used at

* A paper presented at the meeting of the International Railway General Foremen's Association, Chicago, September 28, 29, 1937.

† Car Foreman, Norfolk & Western.

Fabricating the cross bearers in jigs

At station No. 4 on the assembly line

Adjacent to station No. 5 the sides are assembled on jigs

The ends and slope are assembled as a unit and lifted over to the assembly line

times to reinforce men with heavy work in order to keep the line moving on schedule time. In placing the men at the different operations, it is important that the right man be selected for a certain job. This feature requires a good deal of study on the part of the supervisors in order to keep the operations well balanced. To further facilitate the steady movement, the prepared material required at each station is stored adjacent thereto.

Specially-built elevated conveying trucks are used to convey the car frames along the construction line for the body assembling. These trucks are so built as to provide a sufficient amount of space between the cars to avoid cramped working conditions, and riveting can be done without interference from these trucks. The cars are pulled through the construction stations, each car being fastened to the preceding car, with the car in the last station attached to an electric winch, which operates a cable for pulling the cars.

Construction Operations

Station No. 1—Construction is started with the center sills, which move from the machines, upside down, to a rail table. This enables the first operations to begin from the bottom side of the sills without turning them over. These operations consist of burning out key slots, pipe slots, fitting and riveting combination back stop castings, combination striker castings and draft lugs, applying center brake pipe and pipe clamp brackets.

Draft gears, yokes and yoke fillers, draft keys and retainers are assembled and applied in units.

Brake cylinders and brake regulators are riveted on as the last operation.

The assembled sills are then turned over by crane to an upright position.

Station No. 2—Two elevated conveying trucks are spotted and the center plates and the body bolster plates are placed on these trucks. The crane then places the assembled center sills on these trucks. The first operation after the sills are placed on the trucks is fitting on the body bolsters and side bearings. The cross bearer bottom cover plates and the cross bearer diaphragms, also the channel floor supports are then fitted. The connection angles for floor supports are also applied. Jig gages are used, extending from body bolster to body bolster, which are attached to cross bearers to gage the sides and hold the car square as it is built up. The final operation at this station is inspecting and reaming all the fittings made up to this operation.

Station No. 3—After the cars are spotted at this station, the riveting is done in the fittings that have been previously set up at Station No. 2. The air brakes and such other small fittings that can be applied without interfering with the application of the sides, floors and ends are also put on and riveted. The car is then moved to Station No. 4.

Station No. 4—At this station the floors or slope sheets are put in position with such fittings as can be fitted without interfering with the sides and the riveting continued.

Station No. 5—Located adjacent to this station are the jigs and tables for assembling and completing the sides. The assembled sides are put in place by the cranes, the ends are completed and also the lower section of the slope sheets.

Station No. 6—At this station all parts that could not be previously attached on account of interfering with the sides are applied and the riveting continued.

Stations Nos. 7, 8, 9—These stations might be termed finishing stations for the reaming and riveting, and the installation of the remaining air brake parts. The cars are completed at these stations except for the doors and

the electric welding. The cars are then put on trucks, as the truck assembly track is located parallel to these stations.

Station No. 10—At this station the track is elevated on trestle work, which is about 3 feet high and approximately 40 feet long. This is used for the fitting of the drop doors on hopper cars, as it has been found that a better fit can be made by assembling them on the cars. On rebuilt and heavy repair cars, all truck work except wheels, bolsters and truck sides, is done at this station. The elevation of the track makes the underside of the car easily accessible to the workmen. The coupler height is also adjusted at this station.

Station No. 11—This is an electric welding station, at which the construction work is completed. It has been determined by experiments that welding of some of the sheet connections on steel cars is more economical and just as effective as securing with rivets. On gondola cars, the floor is made by using two sheets per car, welded together. The two sheets are also welded to the center sills, through holes punched in these sheets. On hopper cars the center transverse sheet and floor sheets are welded to the side sheets; and to successfully weld them, it is necessary to hold the joints tight; and to accomplish this, a pneumatic clamp was devised to hold all four sections at one time. The box packing and the testing of air brakes is done at this station.

Painting and Weighing

After the welding is completed, the cars are moved to an open track, where all scale is removed from the structure and made ready for painting. The cars are then moved to the painting tracks, which are located some distance from the construction tracks. Painting is done with spraying machines and does not interfere with the construction forces. The painting consists of one coat of red lead and two coats of black paint. The red lead is allowed to stand 48 hours in order to make sure it is thoroughly dry, while the black paint is allowed to stand 24 hours between coats, this depending on the weather to some extent.

After the last coat of black paint has been applied and is dry, the stencilling is applied with a small spray, which is preferable to a brush.

During the construction of the cars, red lead is very freely used at all connections or lap joints. This is beneficial in protecting the steel from corrosion. Where welding is done on the inside of the car, the seams are red leaded and then given a coat of car cement.

The finished cars are then light weighed on the scales adjacent to the painting track and released for service.

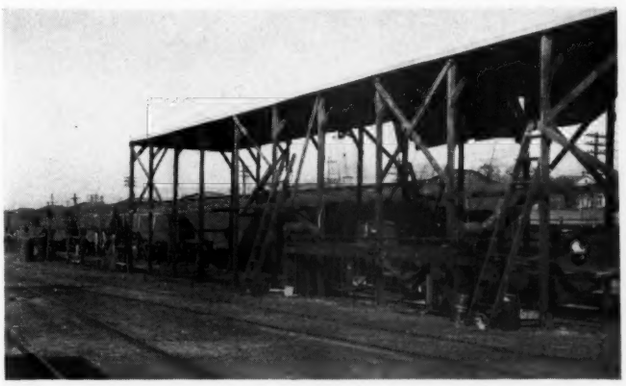
Rebuilding or Heavy Repairs — Steel Cars

In doing this class of work, the cars after they reach the repair line follow very much the same procedure in the course of repairs as that outlined previously for the construction of new cars. However, there is much of importance to be done on this job before the cars reach the shop.

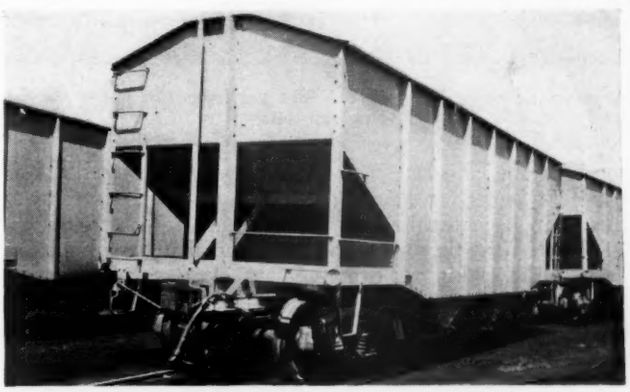
First, after it is determined in advance of the operation the series of cars and how many are to be taken care of, the next move is for the drawing office to get out the original plans and make such alterations as are necessary, after conference with the car supervisors. It is highly important that this be done in order to get the best out of the money to be expended. Certain parts of the cars should never be restored to their original design if failures have occurred to any extent. They should be changed, strengthened and renewed to prevent the possibility of a second failure.

After it is determined that certain items will be re-

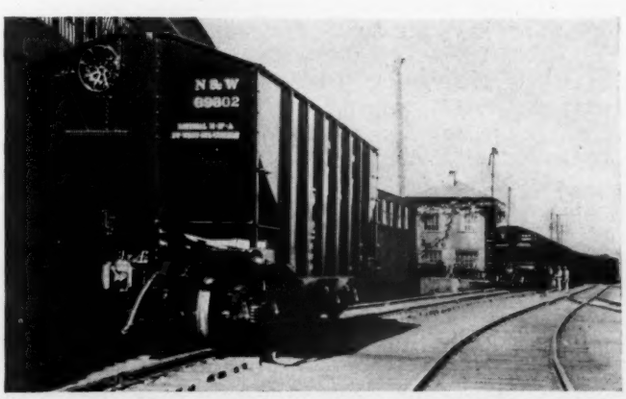
After placing the body on trucks, assembled adjacent to the line, the cars move to an elevated track where hopper doors are put up



General view of the welding station with line of completed cars before painting

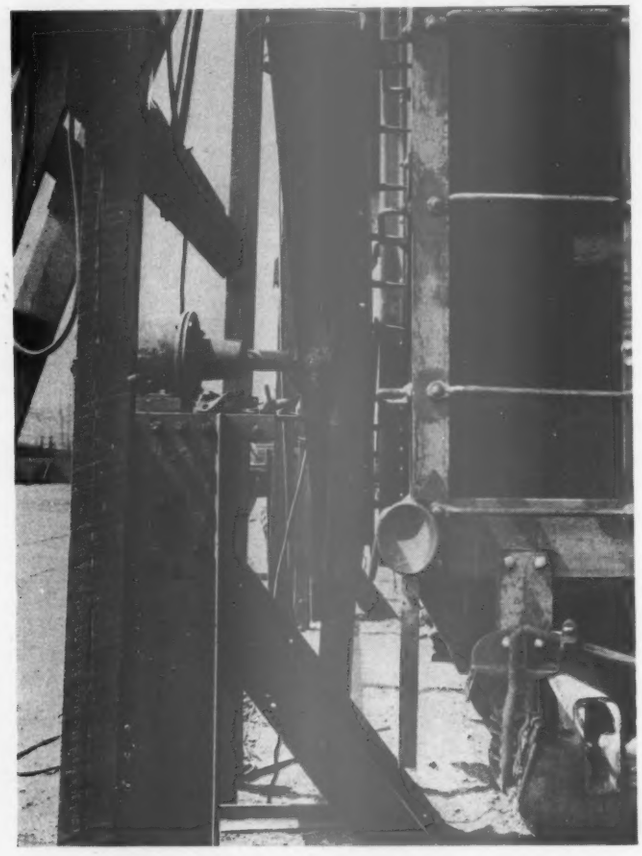


A completed car after a coat of red lead



Weighing the cars before turning them over for service

newed completely on each car, an estimate is then made to determine the percentage of the items of miscellaneous parts required. This gives the stores department a reasonably close estimate as to the exact amount of material needed. The orders are then passed to the stores department for ordering the material. When the material is



A pneumatic clamp holds the car sides and forms the ground for the welding sets

received the fabrication is started by preparing the 100 per cent items for blocks of two to three hundred cars, this is to be determined by the output.

Up to this time, which usually consumes about 90 days in the making of drawings and securing of material, the cars to be repaired have remained in service. The next move is then to cut these cars out of service in the yards adjacent to the shop, the number depending upon the rate established for the output. This insures the cars all being in service a maximum length of time and also being out of service for repairs the minimum length of time—the ordinary average out of service running about eight to ten days per car.

Operations Similar to New Cars

The cars cut out of service are then moved to the scrap wharf which is adjacent to the repair line, where the cutting gangs proceed to cut loose the parts to be replaced, scrap being loaded as it is cut. This insures a minimum handling of scrap. What is left of the car is then moved to the repair line and finds its way through the progressive movement similar to the new cars. When these cars are started through the progress line, the car bodies are set on temporary trucks, the regular trucks are removed and overhauled on the truck track and the replacing operation is the same as for the new cars. This insures complete and thorough inspection and repairs of the old trucks.

Informal Discussion Of Car Questions

At the May meeting of the Northwest Carmen's Association a series of questions pertaining to various car subjects was deposited in a box, drawn at random and submitted for discussion in open meeting by the car-department supervisors and car inspectors present. The discussions of some of these questions are given below, not as authoritative answers to the various points raised, but simply as the view of the association regarding a few of the many important questions which confront car men. Some questions, submitted in writing after the May meeting, were answered by the association's A.A.R. committee. Part of the questions and answers are included here. Others will appear in a later issue.

Question.—What causes waste grabs? What effect will a waste grab have on a journal and bearing? What can be done to prevent waste grabs?

O. J. Lystad (C. St. P. M. & O.)—I would say that heavy switching is one cause of it, and the effect on the journal is to heat and cut it.

D. S. Harrington (C. M. St. P. & P.)—We ought to have some discussion on this one. I have heard it discussed for years, from every possible angle. Some think that it is caused by swaying of cars on rough tracks, some think low joint or small pieces broken out of rail will cause it. While it may be possible that a low joint or piece missing from rail can cause it, I think the largest single cause is fast switching, particularly on empty cars.

I have an instance in mind which I think bears this out. A couple of years ago we were getting from one to three or four waste-grab hot boxes on every ten or less cars received from an industry located several miles from our yard. I was told these cars were handled roughly while being spotted for loading and passed the information along to my foreman, who took it up in the right quarters. The operating department seems to have co-operated, as the waste-grab hot boxes suddenly disappeared. I think it is also possible to get a waste grab when brakes are applied suddenly with cars running.

G. Schadegg (C. G. W.)—A low joint will cause a waste grab, because one pair of wheels will dip down into the low joint while the other wheel is up high. It has a tendency to raise the packing on one side and the brass will grab it. I have seen it happen, I was standing by one of these low joints when three or four heavy gondolas passed over, and one box had no cover on it. I saw the brass grab the packing and by the time this car was switched on the coal dock about a mile away it was starting to heat and the waste grab was plainly visible.

D. S. Harrington (C. M. St. P. & P.)—I have never seen an instance where I could be sure a waste grab was caused by low joint or broken rail, but have caught several immediately after rough switching.

Question.—Is the handling line justified in billing for renewal of dustguards when wheels are changed due to handling line defects—such as slid flat, etc.?

D. S. Harrington (C. M. St. P. & P.)—We have a bill clerk here, I believe, Mr. Williamson.

J. A. Williamson (C. St. P. M. & O.)—That is a no-bill.

Question.—Under what conditions is damage to an end valve on a passenger refrigerator in freight service cardable in interchange?

D. S. Harrington (C. M. St. P. & P.)—This is one for a passenger man.

A Member—I would say that is covered in Passenger Rule 8. It has to be completely missing.

D. S. Harrington (C. M. St. P. & P.)—As I understand, broken by passing coupler is a handling line defect. Passenger Car Rule 8 specifies several things—coupler passing or replaced with elbow or other fittings.

E. N. Myers (C. I. I.)—Passenger Car Rule 8 says it is cardable any time due to any Rule 8 condition, even damage due to couplers on a passenger car is cardable.

J. Chalmers (C. St. P. M. & O.)—Is it considered a passenger car regardless of the fact that it is in freight service?

E. N. Myers (C. I. I.)—Yes, a car of passenger car construction is a passenger car regardless of service it is in.

Question.—There are some cars equipped with a hook-type brake-beam hanger on which it is impossible to apply the new Ajax No. 15 brake beams without changing the hangers. Are we permitted to charge for the hangers which it would be necessary to manufacture in order to apply the No. 15 brake beam?

J. A. Williamson (C. St. P. M. & O.)—I would say yes on that. I believe it is Rule 17 that gives you permission.

Question.—When a journal-box bolt is short allowing the application of only one common nut, is this nut chargeable to the owner?

O. J. Lystad (C. St. P. M. & O.)—No. Rule 64 applies.

Questions Answered by Northwest A.A.R. Committee

Question.—Are Pennsylvania cars equipped with Type AB brakes and marked "Experimental" still considered to be experimental or should they be cleaned, oiled and tested at the expiration of 36 months?

Answer.—The original test of AB brakes on Pennsylvania cars marked AB Experimental was closed Dec. 31, 1936. The AB brakes on these cars are now handled the same as other AB brakes in accordance with Rule 60. The experience gained during these tests indicated that slight improvements could be made.

On account of these changes and to gain further information, there have been an additional lot of 699 Pennsylvania cars, No. 59065 to 59413, 59450 to 59499 and 59500-59799 also 500 A. T. & S. F. cars No. 34000 to 34499, equipped with AB brakes and stenciled AB Experimental as covered by Circulars DV 887 and DV 887-A. The AB brake equipments on these cars are to be handled the same as the experimental AB brakes.

Question.—In connection with Loading Rules, Fig. 6, covering the loading of two or more piles of lumber on flat cars, the question has come up if, with long material loaded first on a flat car about one-half way up, two distinct piles are loaded on top of this long material, 4-in. by 4-in. bearing pieces are required under the outside ends of end piles?

Answer.—The loading rules do not call for the bearing pieces on such loads.

Question.—At a certain street crossing in making the coupling, two knuckles are broken in the same car in succession in the same end of the car. Are both knuckles chargeable to the car owner?

Answer.—Yes.

Question.—Some billing departments ask to have the total length of pipe shown when the thread only is cut on the end of a train line or retainer pipe. A.A.R. Rules allow a certain charge for cutting each thread. Is it necessary to show the length of the pipe on which the thread is cut?

Answer.—Not necessary.

Question.—As air brake man, I have been finding a number of AB release-valve-handle end plates bent and release valves stuck. I believe it is due to some extent to the ½-in. heavy release rod with which these cars are equipped. I would like to know if any of the other railroads are finding the same condition.

Answer.—There have been a number of cases where the AB release-valve-handle and end plates were found bent causing release valves to stick open. This was believed due to rough handling rather than the size of the release rod.

The position of the release valve made it convenient to kick these valves open, which sometimes caused the handles and end plates to bend or break.

This condition was brought to the attention of the manufacturer and the following changes have been made: The end plate is now a one-piece steel forging with a thicker base and four spokes instead of three which will stand a pull 10 times that required to break the old type; the new handle is shortened $^{15}/_{16}$ in. in overall length, it being claimed that the shortening of the handle reduces the force developed and provides increased force for returning the operating rod to release position.

Question.—Rule 23, Sec. 5, says: "The surface where new material is to be deposited must be clean and bright and reasonably smooth, and, therefore, if the surfaces are prepared by the burning process the surfaces must be finished by chipping before welding."

What is meant by chipping? Does a few chisel marks on the face of the cut constitute "chipping" as used in this rule? If chipping does not mean removing all of the thin film of oxidized metal covering the surface prepared by the burning process then how much of the surface must be cleared of this oxidized metal to meet the requirements of this rule?

Answer.—The surface must be entirely clean; a mere chipping is not sufficient.

Question.—It is noted that spring cotters and split keys that are undersize are being applied in journal-box lid pins, brake-hanger pins and brake-connection pins. Is the car owner being billed for such spring cotters and split keys?

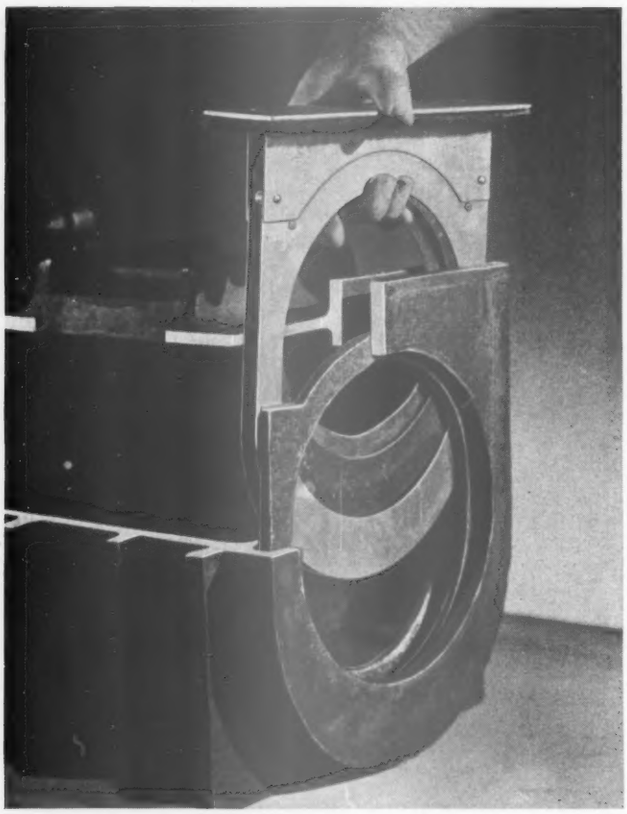
Answer.—Car owner should not be billed unless cotters and split keys are applied in accordance with Rule 64.

M-F Dust Guard

A dust guard, known as the M-F, has recently been developed and placed on the market by the MacLean-Fogg Lock Nut Company, Chicago. This guard is designed to seal effectively the well side of the journal box as well as the opening around the axle, and it closes the top of the well so that no dirt can enter and accumulate here.

The construction and method of application of this new dust guard are indicated in the illustration. The dust guard comprises three pieces; namely, a watertight steel and wool-felt gasket that keeps dirt and water out of the back of the box, irrespective of casting irregularities; a floating seal frame and flexible leather washer, encircling the axle, and a riveted pressed-steel frame within which the seal moves up and down.

When the main dust guard frame, containing the seal, is pressed down into position, it is held tightly in place against the waterproof gasket by four small flat springs which press against the side of the dust guard well. An adjustable feature permits the top of the guard, with its felt-lined under surface, to come down firmly on top of the well, regardless of well depth, and thus make an ef-



New type M-F dust guard being inserted in the dust guard well

fective and permanent well closure, irrespective of the roughness of the casting.

The floating leather washer, or seal, moves freely within the main dust-guard frame and contacts the axle with even pressure at all points, thus preventing the development of an oval opening through excessive wear. It can never contact the top of the frame nor get jammed in the dust guard well to be broken or worn by the axle. Moreover, it is said not to be susceptible to deterioration due to the action of oil or water.

The flexible leather washer normally points toward the inside of the journal box, but if it is desired to have it point toward the wheel, an expander ring can be furnished to maintain it in that position until the journal is inserted in the box.

Decisions of Arbitration Cases

(The Arbitration Committee of the A.A.R. Mechanical Division is called upon to render decisions on a large number of questions and controversies which are submitted from time to time. As these matters are of interest not only to railroad officers but also to car inspectors and others, the Railway Mechanical Engineer will print abstracts of decisions as rendered.)

Failure to Show Proper Description of Cause for Renewing Steam-Heat Hose

On April 19, 1934, at Denver, Colo., the Union Pacific made repairs to a Wabash (American Refrigerator Transit Company) express refrigerator car which included using the repair-card description, "A-1 new 5-ply steam hose applied." In the "Why Made" column the initials "B. O." were inserted. Charges were made for a new steam hose and the undescribed item removed was credited as a defective ordinary hose in compliance with Item 17, Passenger Car Rule 22. The car owner took exception to the credit allowance, claiming that the defective item removed was a standard metallic connector and that proper credit should have been allowed according to Item 39 Passenger Car Rule 22. Subsequently, on August 28, 1934, joint evidence was executed at Decatur, Ill., by the Wabash, and forwarded to the Union Pacific in support of the previously mentioned exception to the credit allowance and as authority to cover the adjustment of labor involved in correcting the wrong repairs.

The car owner stated that the car was equipped with metallic steam connectors as a standard and was so stenciled, and that the Union Pacific, in crediting an ordinary hose, violated the A.A.R. principle established in Interpretation 1 to Freight Car Rule 8. It was further stated that no repairs had been made to the metallic connectors in the time intervening between the original standardization and the Union Pacific repairs in question. The car owner contended that the failure of the repairing line to include sufficient information on repair records to permit intelligent billing cannot be held to justify the assumption of repair information necessary to credit an undescribed part removed at $3.50 instead of an alternative $22.45. The car owner contended further that the mishandling provides no opposition to the exception based on car standard equipment supported by Interpretation 1, Freight Car Rule 8, Interpretation 3 to Passenger Car Rule 16 and, finally, joint evidence submitted in accordance with Freight Car Rules 12 and 13, supported by Passenger Car Rule 5.

The Union Pacific contended that its billing repair card complied with the requirements of Interchange Rules 7, 8 and 9 and that, except as otherwise specified, a detailed description of parts removed is not required when material is renewed in kind. The Union Pacific stated that the interchange record referred to by the car owner classifies the part in question as "hose" which term is used in Interpretation 3 to Passenger Car Rule 16 and that, in itself, fully identifies type, making the use of the word "rubber" unnecessary. The Union Pacific pointed out that the joint evidence submitted did not prove a metallic connector had been removed and therefore cannot be considered sufficient to justify a claim for credit for a metallic connector on the grounds that a joint evidence card is final. The Union Pacific stated that under rules in effect prior to Aug. 1, 1934, it is not responsible on the basis of perpetuation, and as the A. A. R. recommended-practice steam hose was a proper substitute for a metallic connector, its subsequent renewal in kind by the Union Pacific cannot be classed as wrong repairs.

In rendering a decision on November 12, 1936, the Arbitration Committee stated: "Car was received on the line of the Union Pacific April 18 and repaired April 19, 1934. At that time Passenger Car Rule 8 did not classify as delivering-line defect steam heat hose applied in place of metallic steam connector.

"No conclusive evidence is presented by car owner to substantiate statement that the Union Pacific removed a metallic steam connector, nor does the joint evidence sustain claim that car was stenciled therefor.

"However, the use of initials "B. O." cannot be accepted as proper description of cause for repairs and, for this reason, the charge for steam heat hose applied April 19, should be withdrawn."—*Case No. 1750, American Refrigerator Transit Company versus Union Pacific Railroad.*

A German Passenger Locomotive Designed for Burning Pulverized Coal

—Courtesy German Railroads Information Office, New York.

NEWS

German Passenger Locomotive for Burning Pulverized Coal

AN express passenger locomotive having the appearance of a streamline Diesel-electric locomotive, but using pulverized coal for fuel, has recently been completed for the German Railroads by the Borsig Works, Berlin, Germany. The locomotive runs with the firebox and cab at the front end, with the tender coupled back of the smokebox. The supply of pulverized coal from the tender is automatically controlled. The locomotive has 80.6-in. driving wheels and is the first passenger type to be built in Germany for burning pulverized coal.

Report on Cooper-Nightingale Auto Loader

A "SECOND progress report" prepared by the Division of Engineering Research of the Association of American Railroads on the Cooper-Nightingale auto loader covers the new design and present status of that device, which for the past year has been under study by the Research division in collaboration with a committee of the A.A.R. Mechanical division and other organizations. During the past two months, the report points out, the Pullman-Standard Car Manufacturing Company has made a new design of the loader for the purpose of placing it on a production basis and thereby reducing its cost.

The loader provides a means of loading four automobiles in a 40 ft. 6 in. box car. Two automobiles are supported on inclined decks while the other two rest on the floor of the box car underneath the inclined decks. New features incorporated in the Pullman design included: (a) Decks and auxiliary equipment in general made of Cor-Ten steel in form of pressings and using spot-welded connections; (b) hoists mounted on one side of the deck; (c) a new design of tie-down, which has reduced the cost of this part of the equipment; (d) a new design for indexing the front end of the deck. "In the redesign of this loader," the report states, "none of the good features of previous designs, such as safety, flexibility, ease of inspection, has been sacrificed."

D. & R. G. and Santa Fe to Rebuild Enginehouses

THE *Denver & Rio Grande Western* plans to rebuild immediately its coal chute and enginehouse at Thistle, Utah, which were totally destroyed by fire above the foundations on September 17. The same fire also destroyed the combined machine shop and powerhouse at the same point. The property loss totalled about $40,000.

The Atchison, Topeka & Santa Fe.—The work, necessitated by the increased size of locomotives now in use, involves the tearing down of nine stalls of the enginehouse and the reconstruction of six stalls and a machine shop. The new stalls will be 132 ft. long and will be constructed of structural steel encased in concrete, with brick curtain walls. Because of the necessity of placing the enginehouse in operation at the earliest possible date, the construction work is being carried out by two shifts daily.

Building Program of the L.M.S.

THE London, Midland & Scottish (Great Britain) is engaged in an extensive building program in both rolling-stock and structures. Equipment plans of the road call for the construction of 1,160 freight cars, comprising 500 twenty-ton ore cars, 650 merchandise box cars and 10 eight-wheel heavy-duty units.

A new modern coach shop and sidings, designed to augment the existing facilities at Euston station, London, and estimated to cost £500,000 ($2,480,000), marks the first step in a long-term plan to reconstruct the famous London terminal. The new shop, which will be fully equipped for vacuum-cleaning, steam-heating and battery charging, will provide accommodations for 600 coaches, with facilities for preparing, under cover, 200 coaches at a time. The first locomotive testing plant in Britain is now under construction jointly by the L. M. S. and the London & North Eastern at Rugby.

Steam Locomotive Development Committee Appointed

RELATIVELY few changes in the personnel of standing committees of the A.A.R. Mechanical Division are shown in Circular No. D.V.-925, recently issued by the secretary's office, with the exception of the appointment of a special committee on "Further Development of Reciprocating Steam Locomotives." The membership of this committee includes: Chairman D. S. Ellis, chief mechanical officer, Chesapeake & Ohio, Cleveland, Ohio; Vice-Chairman W.

I. Cantley, mechanical engineer, Lehigh Valley, Bethlehem, Pa.; W. R. Hedeman, assistant to chief of motive power and equipment, Baltimore & Ohio, Baltimore, Md.; J. E. Davenport, assistant chief engineer of motive power and rolling stock, New York Central, New York; W. R. Elsey, mechanical engineer, Pennsylvania, Philadelphia, Pa.; J. M. Nicholson, acting mechanical superintendent, Atchison, Topeka & Santa Fe, Topeka, Kan.; Lawford H. Fry, railway engineer, Edgewater Steel Company, Pittsburgh, Pa.; W. E. Woodard, vice-president, Lima Locomotive Works, Inc., New York; H. Glaenzer, vice-president, Baldwin Locomotive Works, Philadelphia, Pa.; J. B. Ennis, vice-president, American Locomotive Company, New York; E. G. Bailey, vice-president, Babcock & Wilcox Company, New York; and Edward C. Schmidt, professor of railway engineering, University of Illinois, Urbana, Ill.

Head Freight Brakemen to Ride Cushions; and Have Heaters

HEAD brakemen on freight trains will henceforth ride in heated quarters fitted with spring cushion seats with arm and back rests, as a result of an agreement announced on October 13 between the Brotherhood of Railroad Trainmen and the Association of American Railroads.

The joint statement in this connection from A. F. Whitney, president of the B.R.T., and J. J. Pelley, president of the A.A.R., says that under the agreement, effective November 1, "spring cushion seats with arm and back rests will be provided head brakemen and will be installed on locomotives used for freight service, combination freight and passenger service, and combination freight and helper service. Such a seat either will be installed in the locomotive cab or in a shelter cab placed on the tender of the locomotive, the location being optional with the railroad. Heaters are also to be provided in the shelter cabs in territories where necessary.

"The railroads are allowed five years in which to install such seats in locomotives coming under the agreement. All new locomotives covered by the agreement, however, will be equipped when built.

"The negotiations between the trainmen and the railroads resulted from a complaint filed by the former with the Interstate Commerce Commission in an effort to have an order issued requiring that such seating facilities be furnished by all railroads. As a result of the agreement the Brotherhood of Railroad Trainmen has asked the commission to dismiss the complaint."

P & S Division Selects Committees

THE Purchases and Stores division, A.A.R., has announced the selection of subjects for study this year and a tentative list of the committee membership. Five new subjects, Special Purchasing Statistics; Efficient Methods of Transporting Company Materials and Prompt Unloading of Equipment; Receiving Records; Stores Organization, Office Practices and Records, and Quantity Price Differentials have been selected, and three committees, Purchasing and Store Department Manual; Shop Manufactured Materials, and Terminal Railway Storekeeping, have been revived. An advisory committee consisting of the past chairmen of the division, under the chairmanship of E. A. Clifford, general purchasing agent, C. & N. W., and a special purchasing committee consisting of nine purchasing officers, under the chairmanship of A. C. Mann, vice-president, I. C., have been continued, as well as the so-called group organization for holding purchasing and stores meetings in different territories. New chairmen have been selected for all committees, with the exception of the committees on scrap handling, general reclamation, stores expense, forest products, fuel, stationery and printing and simplification. The appointments to some of the new and re-organized special and subject committees are as follows:

Railroad Scrap: W. J. Sidey, supervisor scrap and reclamation, L. V., chairman; E. J. Becker, district storekeeper, S. P.; D. D. Canavan, general foreman reclamation plant, B. & M.; J. J. Collins, supervisor scrap and reclamation, Erie; I. T. Goodloe, division storekeeper, Southern; R. R. Kane, division storekeeper, L. & N.; C. L. McIlvaine, assistant purchasing agent, Penna.; C. E. Reasoner, assistant district storekeeper, M-K-T; T. H. Ryan, assistant purchasing agent, Wabash; J. A. Sims, care purchasing department, C. & N. W.; H. E. Warren, manager purchases and stores, G. M. & N.; J. C. Kirk, assistant general storekeeper, C. R. I. & P., chairman ex-officio.

General Reclamation (Joint with Mechanical and Engineering divisions): A. L. Prentice, manager scrap and reclamation, N. Y. C., chairman; I. C. Bon, superintendent scrap and reclamation, Wabash; E. R. Casey, superintendent reclamation, Union Pacific; R. E. Hamilton, supervisor reclamation, C. & O.; T. J. Hegeman, superintendent scrap and reclamation, C. B. & Q.; W. P. Stewart, supervisor scrap and reclamation, I. C.; Peter Young, superintendent of reclamation, A. T. & S. F.; J. C. Kirk, assistant general storekeeper, C. R. I. & P., chairman ex-officio.

Pricing Methods: G. J. Hunter, traveling material supervisor, A. T. & S. F., chairman; N. B. Coggins, division storekeeper, C. N. O. & T.; L. L. Studer, division storekeeper, M. P.; G. E. Tallmadge, assistant general storekeeper, G. N.; E. G. Walker, assistant general purchasing agent, A. T. & S. F., chairman ex-officio.

Shop Made Materials: B. T. Adams, district storekeeper, I. C., chairman; R. W. Hall, division storekeeper, L. & N.; A. N. Laret, assistant to chief purchasing officer, St. L.-S. F.; W. L. Oswalt, works storekeeper, Penna.; C. J. Vanderbosch, district storekeeper, B. & O.; L. P. Krampf, supply agent, M. P., chairman ex-officio.

Material Handling: A. S. McKelligon, general storekeeper, S. P., chairman; J. M. Lowe, storekeeper, N. & W.; J. V. Miller, assistant general storekeeper, C. M. St. P. & P.; H. E. Ray, general storekeeper, A. T. & S. F.; W. F. Redman, traveling storekeeper, C. & N. W.; H. M. Smith, general storekeeper, N. P.; S. P. Warmack, general storekeeper, I-G N.; G. M. Betterton, purchasing agent, S. P., chairman ex-officio.

Terminal Storekeeping: J. K. McCann, inspector of stores, C. B. & Q., chairman; R. H. Bruckert, storekeeper, Ky. & Ind. Term'l; A. F. Campbell, general storekeeper, Ill. Terminal; F. A. Murphy, district storekeeper, B. & O.; H. A. Smith, purchasing agent, Term'l R. R. Ass'n St. L.; C. W. Yeamans, purchasing and supply agent, C. & W. I.; L. P. Krampf, supply agent, M. P., chairman ex-officio.

Equipment Depreciation Orders

DEPRECIATION rates applicable to the equipment of 12 roads are prescribed by the Interstate Commerce Commission in a recently issued series of sub-orders and modifications of previous sub-orders in No. 15100, Depreciation Charges of Steam Railroad Companies. The composite percentages, which are not prescribed rates but merely the averages of such, range from 2.84 per cent for the Lorain & Southern to 8.82 per cent for the East Washington.

The largest of the 12 roads is the Gulf, Mobile & Northern, the rates for which are prescribed in a sub-order modifying a previous sub-order. Its composite percentage is 4.25 per cent derived from the following prescribed rates: Steam locomotives—owned, 4.13 per cent; steam locomotives—leased, 4.56 per cent; freight cars—owned, 3.75 per cent; freight cars—leased, 7.48 per cent; passenger cars in streamlined trains, 6.53 per cent; other passenger cars owned, 4.55 per cent; passenger cars—leased, 13.01 per cent; work equipment—owned, 3.03 per cent; work equipment—leased, 7.72 per cent; miscellaneous equipment, 24.36 per cent.

Shippers' Advisory Board Discusses Car Construction

AT the forty-fourth regular meeting of the Atlantic States Shippers' Advisory Board, held in the Hotel Robert Treat, Newark, N. J., October 6 and 7, a detailed report was presented by the committee on car construction, under the chairmanship of C. J. Fagg, manager, Commerce & Trade Bureau, Chamber of Commerce of Newark. Among the quotations given from the proceedings of other advisory boards concerning car construction was the statement that "it is our belief that the railroads alone are the best judges as to

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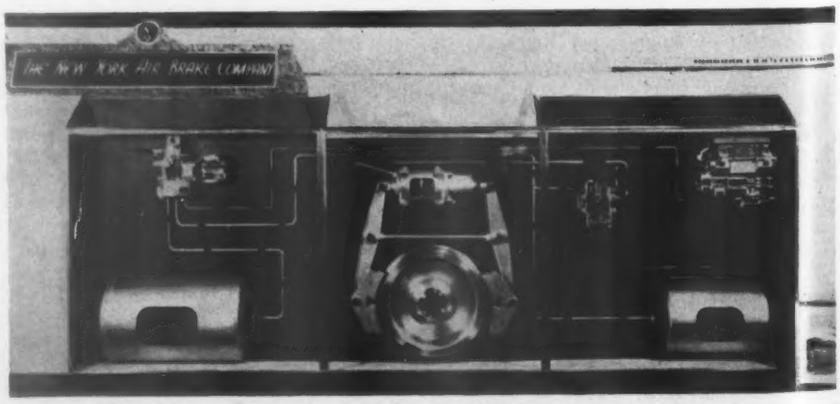
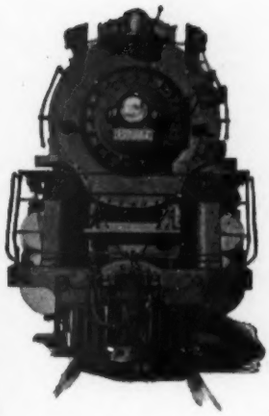


A high-speed train brake working model recently installed at the New York Museum of Science and Industry. (Described in the October issue of the *Railway Mechanical Engineer*, page 506)



MODERN POWER...

Without increase in weight on driving wheels modern power provides—

—25 to 35% increase in ton-miles per hour capacity.

—lower fuel and water rates.

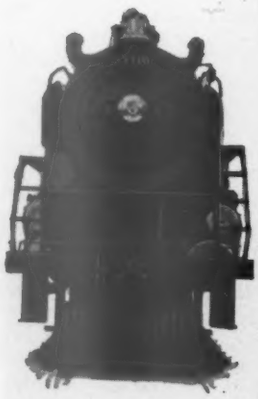
—lower maintenance on track and bridges as well as on the locomotive itself.

—distribution of operating costs over greater tonnage hauled.

—larger gross earning capacity.

—larger net earnings.

Modern Power speeds up train movement and increases the earning capacity of the entire transportation plant.



LIMA LOCOMOTIVE WORKS INCORPORATED

LIMA LOCOMOTIVE WORKS
INCORPORATED, LIMA, OHIO

what cars are required in number and type to properly serve the requirements of the shippers on their respective roads. Varied commodity production necessitates different types and sizes of cars; both our steel and lumber people are constantly advocating the superior quality of their respective products for car construction, and were we to initiate a survey [among shippers] the responses would be more conflicting than helpful."

Commenting upon this, however, the report suggested that "there is laxity on the part of the railroads in not fully informing shippers, as a whole, regarding new equipment; that some railroads are building improved types of equipment and such progress is not being followed by others in a uniform way." The report added: "Your committee is still without information from the carriers as to what method or plans they are following with respect to co-operation with the shippers in creating a change in their equipment or ascertaining the needs of shippers in order to increase their loading, hold and retain their markets and encourage the movement of such commodities by rail."

With respect to the increasing construction of special-type cars, the committee held the opinion that such specialization provides a load only in one direction which appears to the group to impose upon the majority of shippers an unfair burden of transportation costs. This characterization, the committee did not apply to the recently-introduced "removable roof box car," however, averring that, since "the new equipment affords heavier loading and is of such construction, it may be used in general service, eliminating unreasonable transportation costs resulting from inability to get a return load. Carriers should especially study this feature in co-operation with the shipper before adopting specialized equipment," the report added.

The remainder of the report was taken up with a survey of comments received from shippers since a meeting on April 8. Several furnish vigorous backing of the committee's own opposition to over-specialization in car types. Another presents reasons for the adoption of a standard-size box car by the carriers, to be assigned a length of 36 ft. 6 in., holding that shippers be granted the privilege of partial loading or unloading in transit. Such a measure, the comment holds, is dependent upon the application of the same minimum weight, regardless of the size of the car, and the basing of such minimum on the actual loading capacity of a 36-ft. car for each commodity listed in the classification. In support of such a measure the comment points out that "the tendency today seems to be to ship in relatively small quantities, so that a car of 36 ft. 6 in., together with the privilege of partial loading or unloading in transit, should answer the purpose."

In closing, the committee complained that the carriers, failing to ascertain the real needs of shippers, were in many cases building the wrong type of equipment. "It is the observation of your committee that too many railroads are building equipment they believe will be operated solely on the owners line, however, necessity oftimes requires interline movement. This means, therefore, that special equipment is a national problem."

The Board estimated, for the territory within its jurisdiction, an 11.4 per cent increase in carloadings for the fourth quarter of this year as compared with the corresponding period of 1936. This figure was ascertained on the basis of reports delivered by 40 commodity committees, which estimated that the number and kind of cars required through October, November and December would total 701,287, as compared with a record of 629,701 carloads shipped during the identical period of last year.

Speaking on "Possible Legislative Interference with Efficient and Economical Operation of Railroads," M. J. Gormley, executive assistant to the president, Association of American Railroads, argued before the members of the board at the October 7 session that there is no justification for the train-limit bill now pending, expressing the fear that the bill, in its consideration by the House of Representatives, will be treated from a political standpoint. Mr. Gormley also pleaded for strong action against the counter proposal that the power to regulate the length of trains be delegated to the Interstate Commerce Commission, asserting that "the railroads now have all the regulation they can stand and Congress should not interfere with a managerial function of this kind by the passage of a law or by delegation of power to the Commission."

Equipment Building and Repair Programs

The Virginian placed orders recently covering repair material for approximately 800 of its 120-ton gondola cars which the railroad company expects to repair in its own shops at Princeton, W. Va. This is a continuation of a program inaugurated about two years ago covering repairs to a large quantity of its coal-carrying cars.

The Chicago, Burlington & Quincy has announced plans for the expenditure of $4,888,000 for the purchase of locomotives and freight and passenger cars. As soon as arrangements have been made for the sale of the necessary equipment trust notes, which will total $3,650,000, formal inquiries will be issued for 100 Hart ballast cars, 3 stainless-steel dining and 3 stainless-steel chair cars for the "Aristocrat," 2 stainless-steel dinette-coaches and 2 stainless-steel sleepers for the Denver "Zephyrs," and 1 stainless-steel dinette-coach car with kitchen for the original "Zephyr." In addition to these cars, the equipment trust notes will cover equipment to be built in company shops, including 5 locomotives; 250 automobile cars, 100 of which will be equipped with automobile loading devices; 600 box cars; 100 hopper cars; and 400 coal cars, including 100 55-ton cars and 300 50-ton cars.

Supply Trade Notes

F. O. SCHRAMM, manufacturers' representative, 11 W. 42nd Street, New York, has added to his accounts representation of the Grinder division of the Hammond Machinery Builders, Inc., Kalamazoo, Mich.

W. E. CADE, JR., and T. F. Dwyer, Jr., have formed the Cade-Dwyer Company, 683 Atlantic avenue, Boston, Mass., for the continuance of the business established by the late F. A. Barbey, with whom they were associated for years.

GEORGE S. CASE, JR., vice-president and general manager of the Lamson & Sessions Company of Chicago, has been elected vice-president and general manager of the Lamson & Sessions Bolt Company, Birmingham, Ala., to succeed H. P. Ladds, resigned. Mr. Case has been succeeded by William M. Olsen, manager of the stove bolt and machine screw sales department of the Lamson & Sessions Company of Cleveland, Ohio. Mr. Olsen has been succeeded by G. Rider Neff of the sales department at Cleveland. Alexander M. Smith, who has been in charge of the experimental and development department, has been appointed to assistant general manager of the Lamson & Sessions Company of Chicago.

THE ELECTRO METALLURGICAL COMPANY, unit of Union Carbide and Carbon Corporation, New York, proposes to locate a new plant in the Wilson dam, Alabama, area. The plant will be constructed principally for the manufacture of ferro-alloys, calcium carbide, and other electric-furnace products.

W. C. REID, midwestern manager at Chicago of the Matallizing Engineering Company, Inc., has been appointed vice-president in charge of sales, with headquarters at the main office in New York City. Walter B. Meyer, manager of the St. Louis, Mo., office, has been appointed manager of the Chicago office, and Alan B. Geuder, connected with the Chicago office as a salesman, takes over Mr. Meyer's duties in St. Louis.

GEORGE H. CORLISS, advertising and sales promotion manager for the past four years for the Lewis-Shepard Company, Boston, Mass., has been appointed regional manager for the company, with headquarters at 1401 Santa Fe avenue, Los Angeles, Cal. Mr. Corliss was formerly associated with the S. A. Woods Machine Company, Boston; J. A. Fay & Egan Company, Cincinnati, Ohio, and the Kewaunee Mfg. Co., Kewaunee, Wis.

GUSTAV LAUB, general manager of sales, of the Vanadium Corporation of America, New York, has been appointed assistant vice-president and general manager of

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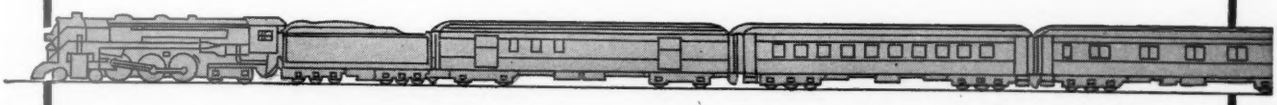
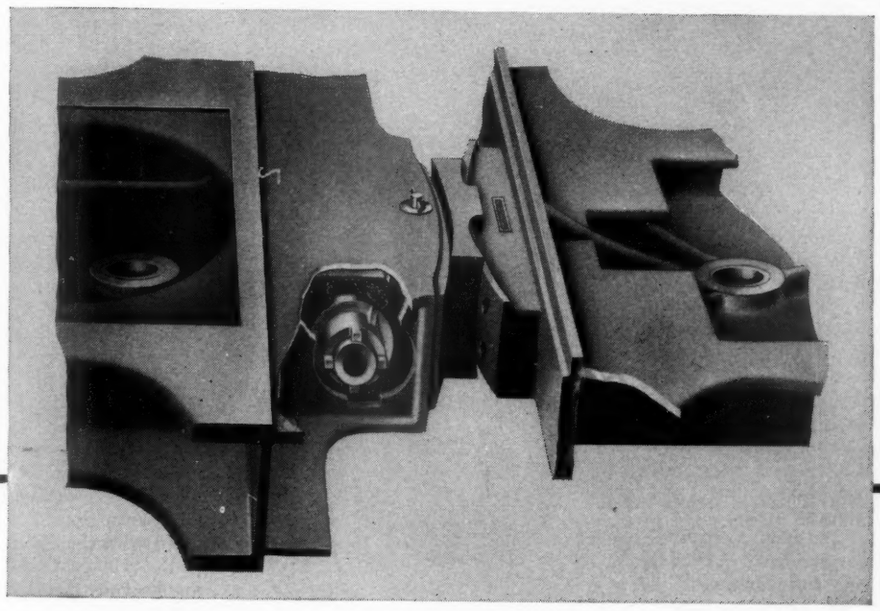
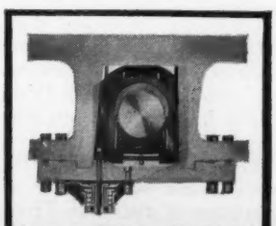
"STEADY MILES"





You never see excessive oscillation between engine and tender on a Radial Buffer-equipped locomotive. » » » The Buffer prevents it by spring-held frictional resistance between the buffer faces, yet at all times movement between these surfaces is unlimited in any direction. » » » By maintaining constant correct relationship between engine and tender and by dampening oscillation, the Type E-2 Radial Buffer vastly improves locomotive riding and safety of operation. » » » Its twin, the Franklin Automatic Compensator and Snubber, maintains accurate driving box adjustment at all times and further improves locomotive riding, reduces maintenance and increases mileage between shoppings.



FRANKLIN AUTOMATIC COMPENSATOR AND SNUBBER

Because material and tolerances are just right for the job, genuine Franklin repair parts give maximum service life.

FRANKLIN RAILWAY SUPPLY COMPANY, INC.

NEW YORK CHICAGO MONTREAL

sales. Mr. Laub is a graduate of the University of Pittsburgh. He became associated with the American Vanadium Corporation, Pittsburgh, Pa., in 1916. After this organization was absorbed by the Vanadium Corporation of America in 1920,

Gustav Laub

he was transferred to the Primos Chemical Company, another Vanadium acquisition, and was later placed in charge of mining properties of the corporation in Colorado. In 1921, he went to the New York office of the Vanadium Corporation of America, and subsequently served as assistant secretary, and assistant general manager of sales. He became general manager of sales in 1931.

THE UNIT TRUCK CORPORATION, 15 Exchange Place, Jersey City, N. J., has recently been incorporated to introduce the "Unit Truck" to the railway trade. The officers and directors of the new company are: Lester A. Crone, president; Alfred F. Crone, vice-president, and Charles R. Busch, vice-president, all of whom are connected with the Buffalo Brake Beam Company.

Lester A. Crone, president of the Unit Truck Corporation, was born on July 25, 1902. He was educated in the public school, East Orange High School, Stevens Preparatory School and Stevens Institute of Technology, receiving the degree of mechanical engineer in the class of 1926. Mr. Crone became assistant to the president of the Buffalo Brake Beam Company in 1926; in 1934, vice-president, and in 1936, president. He will continue in the presidency of the Buffalo Brake Beam Company while serving also as president and director of the Unit Truck Corp.

Alfred F. Crone, vice-president of the Unit Truck Corporation, was born on September 24, 1907, and was educated in the public school, East Orange High School and Stevens Preparatory School. He was a metallurgist in the employ of the Acme Steel & Malleable Iron Works, Inc., from 1927 to 1934. He then became assistant to the president of the company. In 1935 he was appointed assistant to president of the Buffalo Brake Beam Company. This year (1937) he became vice-president of the Buffalo Brake Beam Company, and now becomes also vice-president of the Unit Truck Corporation.

Charles R. Busch, vice-president of the Unit Truck Corporation, was born on January 29, 1892, at Springfield, Mo., and was educated in the public and high schools of Springfield. In 1909 he was material accountant of the Southern Pacific of Mexico at Tucson, Ariz., and two years later became traveling accountant. In 1912 he became stock clerk to the section foreman of the St. Louis-San Francisco; in 1913, foreman of the car material general storehouse at Springfield, and from 1914 to 1917 was foreman and chief clerk of the Frisco reclamation plant at Springfield. In 1918 he was appointed stationery storekeeper of the Seaboard Air Line at Portsmouth, Va., and during 1919 and 1920 was assistant general storekeeper at Portsmouth. In 1920 Mr. Busch became sales representative, eastern and southern districts, of the Buffalo Brake Beam Company, with headquarters at New York. He continues also in this position.

CRAIG W. MARSHALL has been appointed manager of railway sales of the United States Gypsum Company, with headquarters at the company's main office, Chicago.

Craig W. Marshall

Mr. Marshall, who will direct all sales to the railroads of United States Gypsum Company products, began his railroad experience early as an apprentice machinist with the Union Stock Yards Railroad Company. He then attended the University of Valparaiso, Carnegie Institute of Technology, and Ohio Northern University, completing a course in civil and mechanical engineering. Shortly after leaving school Mr. Marshall entered the army as a lieutenant in the Engineer Corps. Following his discharge from the army he was employed by the Concrete Steel Company, Chicago, and soon became assistant western manager, continuing in that capacity until 1922, when he joined the American Arch Company, as district manager of the industrial department. In 1925 he was appointed eastern sales manager of the Sunbeam Electric Manufacturing Company, and continued in that capacity for nearly eleven years.

JAMES A. SLATER has been elected a director of the National Malleable & Steel Castings Company, Cleveland, Ohio, to fill the vacancy on the board caused by the death of Oliver W. Loomis on August 19. Mr. Slater is vice-president of the company in charge of railway sales. He was first employed by the National Malleable Castings Company, a predecessor of the present company, in 1897, and served in various capacities prior to 1913, when he went to Chicago as manager of railway sales in that territory. He returned to Cleveland in 1921 and, continuing in sales work, was elected assistant vice-president in 1931 and vice-president in 1934.

THE TEXAS COMPANY, New York, has made the following appointments in its railway traffic and sales department: W. E. Greenwood has been appointed general manager, Charles Ervin has been appointed traffic manager, and J. L. Lavallee has been appointed sales manager, all with headquarters in the Chrysler building, New York. J. M. P. McCraven has been appointed district manager, railway sales division. Edward Wegner has been appointed assistant district manager, railway sales division, both with headquarters in the McCormick building, Chicago, and A. W. Larsen has been appointed assistant district manager, railway sales division, with headquarters at 1218 Olive street, St. Louis, Mo.

Obituary

ALAN NELSON LUKENS, inventor and chief mechanical engineer of the Railway Steel Spring Division of the American Locomotive Company for about 50 years, died at his home on October 19 at Elizabeth, N. J., at the age of 70 years. Mr. Lukens was born on March 29, 1867, at McKeesport, Pa. He received his education at Pingry School and Stevens Institute of Technology. He entered business in Philadelphia with the Scott Spring Company about 1895, being transferred to New York and becoming chief engineer when the Scott Spring Company was consolidated with the Railway Steel Spring Company. He continued as chief engineer of the Railway Steel Spring Division of the American Locomotive Company when the Railway Steel Spring Company was absorbed by the American Locomotive Company. Mr. Lukens was well known in

A. N. Lukens

railway circles and was a pioneer in many of the developments in the spring industry. He was a member of the American Society of Mechanical Engineers and the American Society for Testing Materials.

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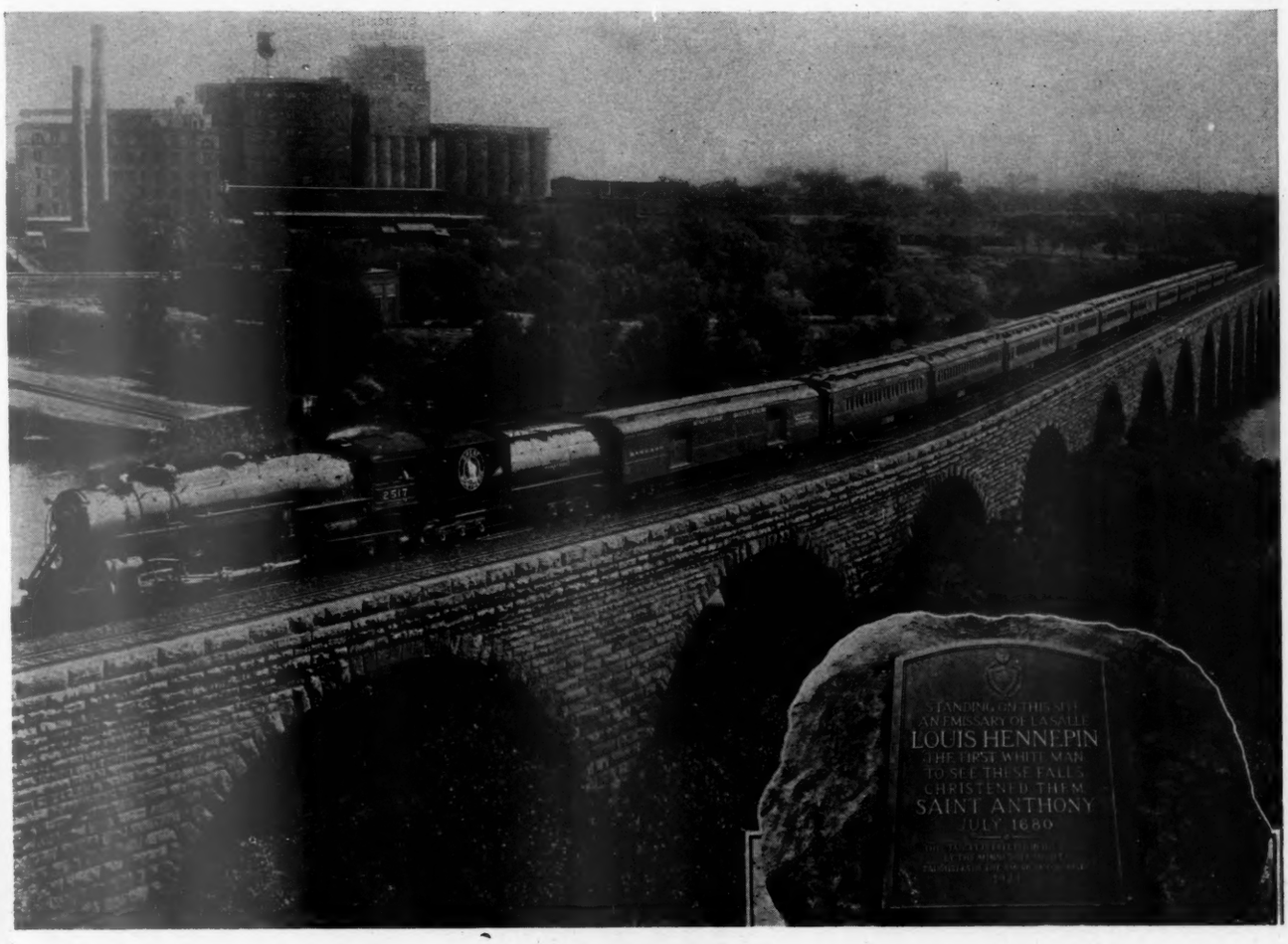
NO. 8 OF A SERIES OF FAMOUS ARCHES OF THE WORLD



THE GREAT NORTHERN BRIDGE AT MINNEAPOLIS

This photograph shows the Great Northern's crack train, the Empire Builder, crossing the Mississippi River over the famous stone arch bridge at Minneapolis. Near the east end of this span is a monument with the following inscription: "Standing on this site Louis Hennepin, the first white man to see these falls, christened them Saint Anthony." The harnessing of this water power was responsible for the growth of the little town of St. Anthony into the present city of Minneapolis. One of the flour mills for which the city is famous is seen in the background.

The bridge, with its massive masonry, lofty arches, and graceful curvature, recalls the solidity of the work of Roman antiquity. It is one of the finest stone viaducts in the world. Because of the length and curvature of the span passengers can see the bridge, and its height also commands a view of the city's skyline.

It consists of 23 arches and is 2,100 feet long, 76 feet high and 28 feet wide. Completed in 1893, it is the only structure on the Great Northern Railway on which is inscribed the name of the founder of the system, James J. Hill, who later became famed as the Empire Builder.

The locomotive shown was the first to make a round trip between the Mississippi River and the Pacific Ocean without a stop except to change engineers and take on water and fuel oil. In one direction it pulled the fast mail train; in the other a silk special. In honor of this 3,700-mile jaunt the name Marathon was assigned in place of No. 2517.

HARBISON-WALKER REFRACTORIES CO.

Refractory Specialists

AMERICAN ARCH CO.
INCORPORATED

Locomotive Combustion Specialists » » »

Personal Mention

General

E. E. MACHOVEC, mechanical superintendent of the Atchison, Topeka & Santa Fe, Southern district, Western lines, with headquarters at Amarillo, Tex., has assumed also the duties of master mechanic of the Plains division of the Panhandle & Santa Fe.

J. D. MUIR has been appointed superintendent of motive power and car department of the Canadian Pacific, with headquarters at Toronto, Ont., succeeding Geo. Whiteley, deceased. Mr. Muir entered the

J. D. Muir

service of the Canadian Pacific in 1905 as a machinist at Moose Jaw, Sask. In 1909 he became shop foreman at Moose Jaw and in 1910 shop foreman at Calgary. He was locomotive foreman successively at Calgary, Alta., Medicine Hat, Alta., and Winnipeg, Man., from 1910 to 1916. In 1917 he became general foreman motive power department, at Vancouver, B. C., and in February, 1919, assistant works manager at Angus shops, Montreal. In 1928 he was appointed assistant superintendent motive power and car department, Western lines, with headquarters at Winnipeg, although for a time in 1933, during the illness of the late George Whiteley, he was acting superintendent motive power and car department for the Eastern lines.

FRANK SHEPPARD ROBBINS, who has been appointed superintendent motive power of the Atlantic Coast Line at Wilmington, N. C., as noted in the October issue of the *Railway Mechanical Engineer*, was born on December 22, 1880, at Menantico, N. J. In March, 1900, he entered the service of the Pennsylvania as a machinist apprentice in the Meadows shops and in September, 1902, was furloughed to enter Purdue University, from which he was graduated in June, 1906, with a B.S. degree in mechanical engineering. In March, 1907, he completed his apprenticeship at the Altoona, Pa., shops of the Pennsylvania, then taking over special duties in the locomotive test plant and in studies of fuel and tonnage problems. From March to May, 1908, he was furloughed for service with the Berwind White Coal Company. In May, 1908, he became fuel inspector of the Cresson division of the Pennsylvania, and in November, 1908, shop inspector at Renovo, Pa. In November, 1909, Mr. Robbins was appointed assistant master mechanic, locomotive and car repairs, of the Monongahela division and in January, 1911, became assistant road foreman of engines of the Renovo division. He became assistant general foreman of the Pitcairn, Pa., car shop in December, 1913, and assistant master mechanic of the Pittsburgh division in July, 1914. In May, 1917, he was furloughed for military service and in March, 1919, returned to the Pennsylvania as assistant engineer of equipment, office of the assistant to president at Philadelphia, Pa. He became master mechanic of the Pittsburgh division in December, 1919, and in March, 1920, was appointed to a similar position on the Pittsburgh Terminal division. In March, 1921, Mr. Robbins resigned from the Pennsylvania and in May of that year became mechanical advisor of the Inter-Allied Technical Board, Trans-

F. S. Robbins

Siberian Railways, at Harbin, China. In December, 1922, he became railway representative of the Pittsburgh Testing Laboratory and in August, 1924, manager of its Philadelphia office. He was appointed superintendent motive power and machinery of the Florida East Coast at St. Augustine, Fla., in May, 1926, which position he held until his recent appointment as superintendent motive power of the Atlantic Coast Line.

E. G. BOWIE, works manager of the Ogden shops of the Canadian Pacific at Calgary, Alta., has been appointed assistant superintendent of motive power, with headquarters at Winnipeg, Man., to succeed J. D. Muir.

Master Mechanics and Road Foremen

W. ALEXANDER has been appointed master mechanic of the Portage-Brandon division of the Canadian National, with headquarters at Winnipeg, Man., to succeed A. Mays, deceased.

LELAND T. FIFE, who has been appointed master mechanic of the San Joaquin division of the Southern Pacific, with headquarters at Bakersfield, Calif., as noted in the September issue of the *Railway Mechanical Engineer*, was born on July 29, 1887, at Ogden, Utah. He obtained his education in the public schools of Ogden and through a correspondence school course. He entered the employ of the Southern Pacific in July, 1905, and until July, 1907, served as an engine wiper, a

L. T. Fife

machinist helper and an electric craneman. He then became, until July, 1911, a machinist apprentice at Ogden. From January, 1912, to September, 1912, he was a machinist and night foreman for the Utah Copper Company at Arthur, Utah; from October, 1912, to March, 1913, a machinist on the Chicago, Milwaukee & St. Paul; from October, 1913, to May, 1914, machine shop foreman, Utah Copper Company, Magna, Utah, and from July, 1921, to December, 1921, a machinist on the Union Pacific at Provo, Utah, and North Platte, Neb. From December, 1921, until his appointment on August 1, 1937, as master mechanic of the San Joaquin division, he has been in the service of the Southern Pacific successively as a machinist, erecting foreman, departmental foreman, general foreman, and assistant master mechanic.

C. D. SMITH has been appointed master mechanic of the Port Arthur division of the Canadian National, with headquarters at Sioux Lookout, Ont., to succeed T. R. Currie, who has been transferred.

C. E. PLOTT, assistant master mechanic of the Galesburg-Ottumwa divisions of the Chicago, Burlington & Quincy at Galesburg, Ill., has been appointed to master mechanic of the Beardstown division, with headquarters at Beardstown, Ill.

DON NOTT, master mechanic of the Beardstown division of the Chicago, Burlington & Quincy at Beardstown, Ill., has been transferred to the Casper division, with headquarters at Casper, Wyo., to succeed C. O. Davenport, deceased. Mr. Nott will have jurisdiction also over the Sheridan division.

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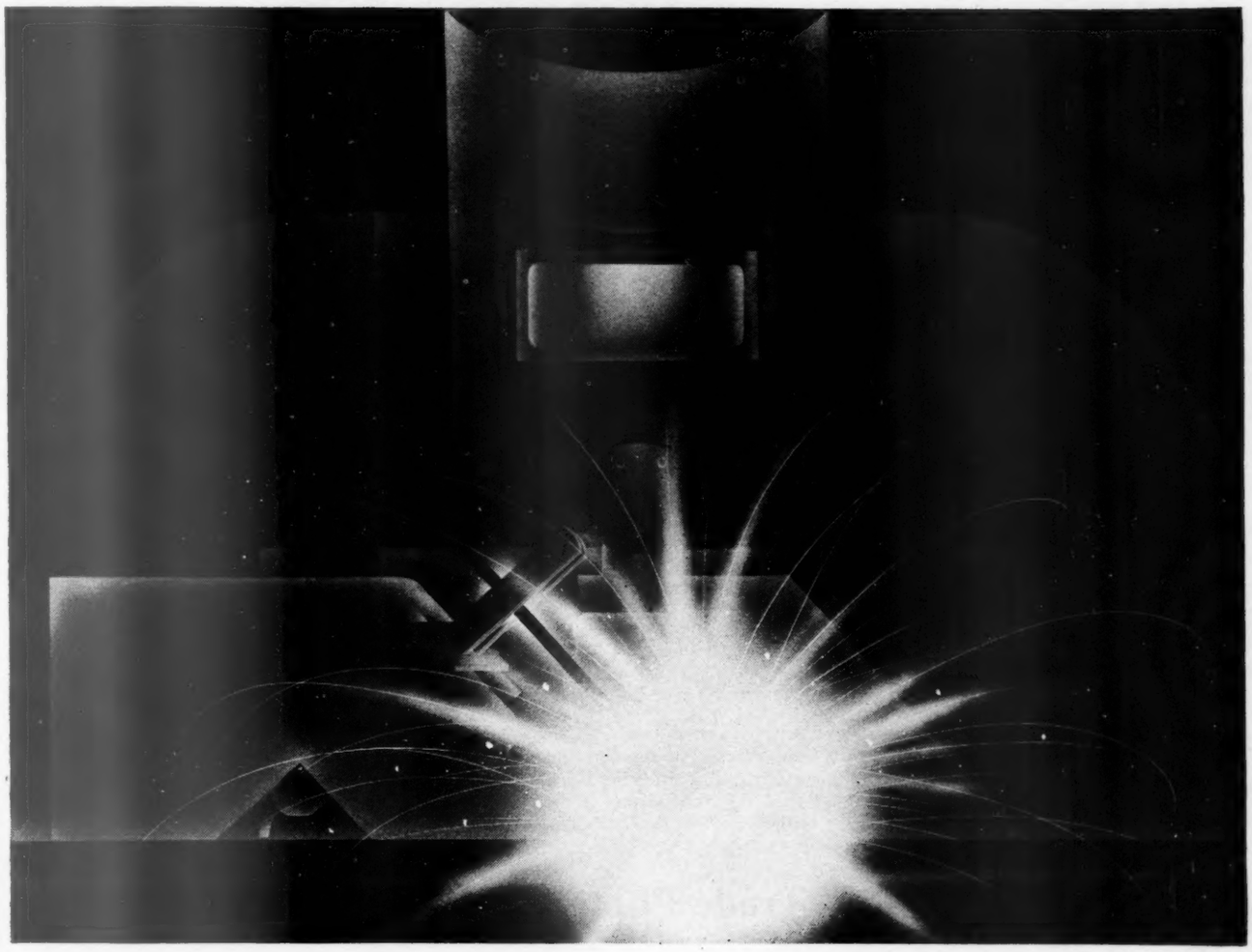

For new requirements . . . MOLY steels

WITH the decided trend toward higher steam pressures and temperatures, there is also a growing tendency toward welded pipe-line assemblies.

Carbon-Molybdenum steel is being used more and more extensively in steamline construction because it meets the stricter present-day requirements: It has good creep strength and retains its strength at elevated temperatures. It lends itself to welded construction. And — its cost is so low, in comparison with its advantages, that in the end it is really the most economical steel for the purpose. In a weldability investigation, tests showed:

At room temperature Carbon-Molybdenum steel was 10% higher in tensile strength and 20% higher in yield point than Carbon steel;

At 950° F. the drop in these qualities respectively was 14% and 15% for Carbon-Molybdenum and 31% and 34% for Carbon;

At 1050° F. the drop in both qualities was 24% for Carbon-Molybdenum and 50% for Carbon.

Our technical book, "Molybdenum," will prove useful to engineers and production heads interested in cost cutting and product improvement. Our monthly news-sheet, "The Moly Matrix," keeps readers informed on Moly developments. Both sent free on request. Our laboratory is available for the study of special ferrous problems. Climax Molybdenum Co., 500 Fifth Ave., New York.

PRODUCERS OF FERRO-MOLYBDENUM, CALCIUM MOLYBDATE AND MOLYBDENUM TRIOXIDE

Climax Mo-lyb-den-um Company

MOLY

J. P. KELLY, master mechanic of the British Columbia district of the Canadian Pacific at Vancouver, B. C., has been appointed works manager of the Ogden shops at Calgary, Alta., succeeding E. G. Bowie.

G. R. MILLER, master mechanic of the Plains division and of the Pecos division of the Panhandle & Santa Fe, with headquarters at Clovis, N. M., is confining his jurisdiction to the latter division.

ARTHUR J. PENTLAND, division master mechanic of the Canadian Pacific at Kenora, Ont., has been appointed master mechanic of the Saskatchewan district, with headquarters at Moose Jaw, Sask.

E. W. FRITTS, road foreman of engines of the Hannibal division of the Chicago, Burlington & Quincy, has been promoted to the position of assistant master mechanic of the Galesburg-Ottumwa divisions at Galesburg, to succeed C. E. Plott.

G. H. NOWELL, master mechanic of the Saskatchewan district of the Canadian Pacific, at Moose Jaw, Sask., has been transferred as master mechanic to the British Columbia district, with headquarters at Vancouver, B. C.

Shop and Enginehouse

MOSES HARRY WESTBROOK, superintendent of shops of the Grand Trunk Western, who retired on September 1, as noted in the October issue of the *Railway Mechanical Engineer*, was born on May 23, 1868, at Writtle, England. He received his education in the public and night schools of Canada, England and the United States. Mr. Westbrook served his apprenticeship at Robert Whitelaw's General Machine Shop, Woodstock, Ont. He later spent two years in England and Scotland, working at the government arsenal at Woolwich; Peter Denny's Marine Works, Scotland; Dryden & Forch Printing Press Works, London, and Maxim Nodenfeldt Gun Works, Erith, England. Returning to Canada, he entered the employ of the Grand Trunk Railway System at Stratford, Ont., on October 28, 1890, serving successively as a machinist, charge hand, and apprentice instructor at Stratford until April 1, 1903, when he was transferred to Port Huron, Mich., as machine shop foreman. On October 1, 1908, he was transferred as machine shop foreman to Battle Creek, Mich. In 1916 he was drafted by the Munitions Board of Canada and for several months superintended shell manufacture at the plant of the Spartan Company, Montreal. Returning to Battle Creek, he became erecting shop foreman on April 1, 1917; general foreman on January 1, 1918, and shop superintendent on November 1, 1919.

Oct., 1890

Sept., 1937

M. H. Westbrook

Trade Publications

Copies of trade publications described here can be obtained by writing to the manufacturers. State the name and number of the bulletin or catalog desired, when mentioned in the description.

TURRET LATHES.—The new Gisholt improved 3AL, 4L and 5L heavy duty turret lathes and optional special attachments are described in the catalog issued by the Gisholt Machine Company, Madison, Wis.

PIPE REPAIR CLAMPS.—The Pipe Repair Handbook issued by the M. B. Skinner Company, South Bend, Ind., describes how to repair various kinds of leaks without shutdown of the pipe line.

INGERSOLL RAY BLADE.—The features of standardization and application of the Ingersoll Ray Blade are described in detail in the eight-page illustrated Ray Blade cutter bulletin issued by the Ingersoll Milling Machine Company, Rockford, Ill.

LANDIS THREADING EQUIPMENT.—The Landis Machine Company, Inc., Waynesboro, Pa., has issued a 16-page bulletin showing how Landis pipe threading and cutting machines cover the requirements for thread-cutting equipment in railroad shops and associated metal-working industries.

WHITING SPECIALTIES. — "Pointing the Way to Lower Repair Costs" is the title of Bulletin No. 220 issued by the Whiting Corporation, Harvey, Ill. In this bulletin are briefly described the advantages of various whiting railroad specialties—Model "B" drop tables; locomotive spotters; automatic car washers; electric turntables; cranes, etc.

FORGED STEEL FLANGES.—The Kropp Forge Company, 5301 West Roosevelt Road, Chicago, in its four-page bulletin covers its line of forged steel stock flanges which includes boiler, tank, welding, offset, double hub, etc.

AIR-BRAKE DEVICES.—Circular Notices Nos. 1111, 1112, and 1113, issued by the Westinghouse Air Brake Company, Wilmerding, Pa., describe, respectively, a cleaning device for AB valve brake pipe strainers; a new double locking angle cock and an improved handle for angle cock, and improved hose fittings.

TEMPERATURE MEASUREMENT AND CONTROL.—The Leeds & Northrup Company, 4934 Stenton avenue, Philadelphia, Pa., in Broadside N-33 on Micromax and other pyrometers, presents four distinct methods of temperature measurement and control—thermocouple pyrometers, resistance thermometers, optical pyrometers, and Rayotube pyrometers, the latter being described as offering full reliability and low maintenance in certain applications within the range of 300 deg. to 5,000 deg. F.

SIGNAL FOAM-METER.—Bulletin No. 376 of the Electro-Chemical Engineering Corporation, 310 South Michigan avenue, Chicago, describes the Signal Foam-Meter electromatic blowoff system. A diagram shows the application of the steam separator system, and boiler cross-sections, in color, show the behavior of boiler water under average operating conditions.

COLOR AND DESIGN.—"Color and Design in Passenger Equipment" is the title of a 26-page brochure issued by the Pullman-Standard Car Manufacturing Company, Chicago, which illustrates the special service provided by this company in executing the interiors and exteriors of passenger cars and trains. According to the brochure this service is complete, embracing architectural features, colors, decorations, fabrics, floor coverings and other details of the finished job. The brochure, printed in colors, gives a striking impression of what has been accomplished with modern materials, fabrics and colors in most of the recent new trains and cars "styled" by Pullman-Standard. The trains illustrated include the Union Pacific "City of Denver," the Illinois Central "Green Diamond," the Southern Pacific "Daylight," the Pullman articulated cars "Advance" and "Progress," as well as some of the cars in the new 14-car streamliners which are being built for the Chicago & North Western, the Union Pacific and the Southern Pacific.